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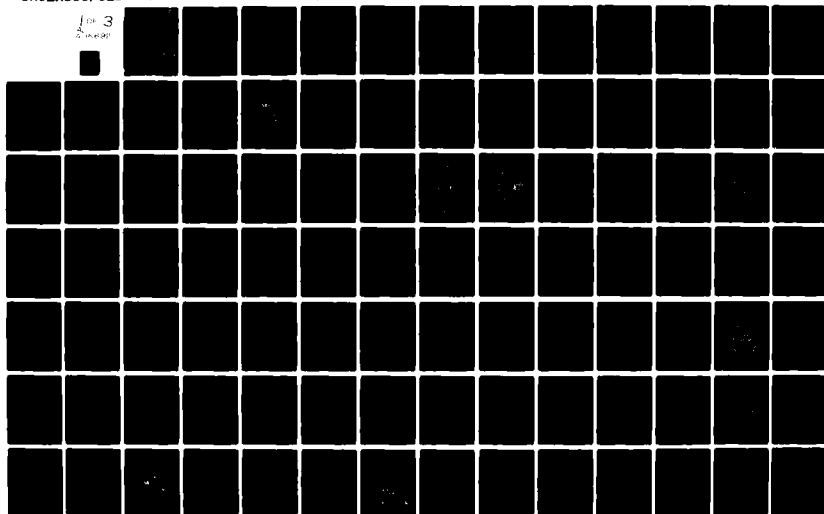
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AN ALASKAN THEATER AIRLIFT MODEL
THESIS

Donald S. Bowers, Jr., Captain, USAF

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AN ALASKAN THEATER AIRLIFT MODEL

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

Donald S. Bowers, Jr., Captain, USAF
Graduate Strategic and Tactical Sciences

19 February 1982

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Preface

This thesis was pursued as the result of a combination of two factors: first, the growing interest in the airlift community in the analysis of airlift capability using computer simulation, and second, the author's five and a half years as a tactical airlift pilot and operational planner in the Alaskan theater. In many ways, this thesis represents the continuation of the author's efforts, begun in Alaska, to promote understanding and effective use of airlift resources in northern areas.

Thanks are due to many people for the inspiration and assistance required to bring this project to completion. In particular, acknowledgment is due to COL William P. Martin, Jr., and LTC Don Smith, whose advice and training in staff work at Elmendorf have proven sound many times over. Also, the author's friends and former associates in the 17th TAS and the 616th MAC deserve a vote of appreciation for their patience and participation in the development of the operational concepts embodied in this thesis.

At HQ MAC/IPS, Mr. Tom Kowalski and his staff were of great assistance in introducing the author to the "real world" of airlift simulation. At AFIT, LTC Tom Clark's solid grounding in the fundamentals of simulation was invaluable. Mr. Dan Reynolds served not only as a reader but as a fellow computer enthusiast. And lastly, many thanks to COL Don Stevens, whose conceptual assistance and guidance as an advisor paid dividends in areas well beyond the scope of this thesis.

Contents

	Page
Preface	ii
List of Figures	vi
List of Tables	vii
Abstract	viii
 I. Introduction and Background	 1
Overview	1
Northern Latitude Warfare in Perspective	2
The Roadless North	2
Effect of Climate	3
Limitations of Geography	5
Importance of Airlift	6
Alaska as a Potential Battlefield	7
Summary of Conditions	7
The "Arctic Rapid Deployment Force"	8
Three Alaskan Scenarios	10
Planning and Exercise Inadequacies	11
Development of Current Concepts	12
Implications for Airlift	14
Exercise ARCTIC CIRCLE	14
Problem Statement	15
Basis for an Alaskan Airlift Model	16
Summary	17
 II. Conceptualisation	 18
System Description	18
Theater Influences and System Boundaries	18
Causal Relationships	21
Sortie Phases	22
Departure Phase	22
Enroute/Approach Phase	25
Arrival Phase	26
Continuation/Scheduler Phase	26
System Operation	27
Typical Mission	27
Summary	31
 III. Assumptions and Limitations	 32
Inputs, Constraints, and Interactions	32
Theater Airlift Requirements	33
Mission/Load Integrity	34
Load Types	35
Load Times	36
Airdrops	37
Priority and Risk	38
Aircraft Limitations	39
Summary of Mission Assumptions	39
Airlift Aircraft and Aircrews	40
Aircraft Types	40
C-130 Model Interoperability	41

Crew Day Considerations	42
Airfield Types and Limitations	43
Main Bases	43
Forward Bases	44
Forward Base Saturation	45
Cargo Handling Capability	46
Number of Bases	47
Aircraft Maintenance and Reliability	47
Home Base Maintenance	48
Aborts	51
Abort Routing	53
Geography, Threat, and Weather	54
Enemy Activity	56
Weather and Darkness	57
Enroute Time	58
Summary of Assumptions	58
IV. Computerization	63
Overview	63
Language and Concept of Construction	63
Network Description	64
Network Circulation	64
Network Phases	67
Home Base Maintenance and Crew Changes	70
Mission Entry	71
Scheduling	72
Special Features	75
Initialization	76
The Master Clock	76
Threat	76
Escort	78
NHE Clocks and Combat Offload	78
Weather	79
FORTRAN Print Routines	79
Output Measures	80
Summary	81
V. Verification and Validation	82
Overview	82
Verification vs Validation	82
Verification	82
Validation Considerations	82
Construction Stages	83
Forward Airhead Model	83
Initial Main Base Model	84
Closed-Loop Test	84
Final Model Testing	85
Scheduler	85
Aborts	87
Significant Problems	88
The "Block-Scheduling" Problem	88
The "Preloading" Problem	88
The "Degraded-Aircraft" Problem	90
Summary	91
VI. Analysis	92
Overview	92
Analytical Considerations	92
Comparative vs Predictive Use	92

Variability of Conditions	93
Importance of Experimental Design	93
Outline of Analysis	94
Scenario and Mission Input	94
Screening Experiment	95
Design Considerations	95
Fractional Factorials	96
Confounding	96
Screening Experimental Design	97
Screening Results	98
Normal Probability Plot	99
Aircraft/Aircrew Analysis	104
Factor Selection	104
Experimental Design	104
Variance Reduction	105
Graphical Analysis	107
Nonlinearity of Effects	107
Operational Value of Analysis	109
Optimum Aircrew/Aircraft Manning	109
Crew Day Considerations	110
Effects of Other Factors	110
Attrition	111
General Observations	112
Summary	113
VII. Conclusions and Recommendations	114
Summary	114
Conclusions	114
Model Viability	114
Significant Factors	115
Aircraft/Aircrew Considerations	115
Recommendations	116
Attrition	116
Additional Bases	117
Maintenance and Aerial Port	117
Interactive Operation	118
Comment	119
Bibliography	120
Appendix A: Network Diagrams and SLAM Program	122
Appendix B: FORTRAN Code	141
Appendix C: Mission Input	216
Appendix D: Glossary	221
Vita of the Author	225

List of Figures

Figure	Page
1. Outline Map of Alaska	7
2. Causal Loop Diagram	23
3. Sortie Phases	24
4. Typical Alaskan Airlift Mission	28
5. Geographic/Weather Zones	55
6. Overall Model Organization	69
7. Scheduler Inputs	73
8. Initialization Sequence	77
9. Normal Probability Plot	102
10. Aircrews vs Aircraft vs Closure Time	108
11. Continuation and Enroute Subnets	123
12. Base 1/2 Arrival Subnet	124
13. Base 1/2 Departure Subnet	125
14. Base 3 Arrival Subnet	126
15. Base 3 Departure Subnet	127
16. Base 4 Arrival Subnet	128
17. Base 4 Departure Subnet	129
18. Base 5 Arrival and Departure Subnets	130

List of Tables

Table	Page
I. Global Variable Listing (Part 1)	65
II. Global Variable Listing (Part 2)	66
III. Attribute Listing	68
IV. Screening Experiment Factors and Design	90
V. Effects of Factors	100
VI. Fiveway ANOVA	103
VII. Aircraft/Aircrew Analysis Run Results	106

Abstract

This thesis studies the problem of analyzing the wartime performance of the Alaskan theater airlift system. Alaska is of particular interest in this respect because airlift is the primary means of movement for the theater; this is in contrast to Europe, where several alternate transportation systems are available.

To examine the performance of the Alaskan airlift system, a simulation model was created using the SLAM simulation language. The model was designed to be used for further study and incorporates a number of features designed to enhance ease of use. The model allows much flexibility in determination of scenarios against an overall background of wartime operation. In general, the model centralizes the system around a home base and circulates aircraft through a network of five bases representing the major types of bases expected to be of concern in the theater.

To simultaneously demonstrate the use of the model and perform an introductory analysis, a specific scenario is created reflecting a major Army movement from the central area of the theater to the western perimeter. Using a 32-run fractional factorial design, fifteen factors are screened for possible significant effects on the final completion time of the 187 missions involved in the movement. With the aid of a normal probability plot and an analysis of variance (ANOVA), five factors (number of aircraft, number of crews, crew day length, season, and weather) are shown to have significant effects. The two most important of these, number of aircraft and number of crews, are then examined more thoroughly using a triply-replicated 80-run factorial design with graphical analysis of the results. The

results indicate that aircraft and aircrews have complex but readily definable effects on system performance, and that analysis of these effects can be of much use to operational planners. Beyond the results drawn from the specific scenario used, this thesis demonstrates that the Alaskan airlift model can be useful in the analysis of a type of theater logistics system which has received relatively little attention in the past.

AN ALASKAN THEATER AIRLIFT MODEL

I. Introduction and Background

The rapid development of critical resources in northern regions of North America suggests that defense of these increasingly important areas warrants increasing concern. The North Slope oil fields of Alaska, for instance, are closer to the Soviet Union than are any Persian Gulf sources. Moreover, the pipeline-tanker system which transports North Slope oil to Continental U.S. (CONUS) refineries is far from secure -- the pipeline itself has already been successfully sabotaged at least once. Although the defense of Alaska and other northern areas is not considered a major priority in light of threats elsewhere in the world, it may be of some value to briefly examine what large-scale operations in northern areas might entail.

Overview. After briefly examining the current positions of the United States and the Soviet Union with regard to northern-area warfare, this chapter will explore the general problems of military operations in northern areas with sparse populations and limited surface transportation networks. The effects of northern climate and geography will be outlined and the value of airlift in such areas will be explained. The Alaskan theater will then be specifically examined as a potential battlefield. Alaskan climate and geography will be summarized and military forces available in the theater will be discussed. Three possible scenarios for enemy activity in Alaska will be presented and recent developments in planning for these scenarios will be covered. Lastly, the need for further analysis of Alaska (and of northern operations in general) will be discussed and the

usefulness of a specially designed simulation model in such an analysis will be outlined.

Northern Latitude Warfare in Perspective

Large-scale operations in cold-weather, northern-latitude regions have traditionally presented major problems to military planners. Inadequate consideration of and poor preparation for these problems resulted in two of the most crushing defeats in military history -- Napoleon's disastrous march on Moscow and Hitler's ill-fated Russian campaign. The United States has conducted only one prolonged operation in near-Arctic conditions -- the Aleutian campaign in 1942-43. Although officially a success, this campaign required 500,000 men and fifteen months to dislodge a few thousand ill-equipped Japanese troops from two tiny islands (Ref 7:iii).

The Roadless North. The same problems which defeated Napoleon and Hitler and which were the true enemy of both sides in the Aleutians are still very much in evidence. However, operations in mainland Alaska and northern Canada complicate the traditional cold-weather problems by removing or severely restricting a factor which made large-scale winter operations even initially feasible -- reliable surface transportation capable of moving large quantities of men and materiel. Alaska and Canada, above approximately 55 degrees north latitude, are effectively roadless except for a very few extremely vulnerable roads and railroads. This means that virtually all of Alaska and more than two-thirds of Canada -- an area of more than three million square miles -- is at once a rapidly developing resource storehouse and a virtual wilderness unsuited to traditional temperate-zone operations. US Army Colonel William Alexander's recollection of

his largely disregarded advice during the planning of the Aleutian campaign is illuminating:

...I pointed out that none of the needs of man were available on Attu and Kiska, and therefore we had an unusual set of conditions to deal with, not to mention the cold temperatures and the muskeg -- muskeg that quakes, shivers, and gives way beneath the weight of a man, let alone wheeled vehicles. I emphasized the utter futility of trying to conduct an operation along conventional lines ... As for supply, I kept in mind that an infantryman equipped for combat could, with luck, make 1-1/2 miles an hour, unopposed, over terrain of that sort. And for every soldier engaged in combat there must be two to carry supplies -- one going and one coming from the front line. We could not do it with wheels or tracks.... (Ref 7:223)

Although the United States and Canada have not much less roadless and sparsely populated northern territory than the Soviet Union, little modern analysis has apparently been done in the United States on the subject of theater-scale war in northern latitudes. Today only the Soviet Union regularly trains for large-scale cold-weather warfare; American efforts have been limited for many years to such exercises as JACK FROST, which have involved no more than battalion-size units in extremely limited scenarios. The scale of these exercises does not compare favorably with the estimated full Soviet division in place on the Kamohatka Peninsula and in the northeast Asian Arctic (Ref 4:355). As a further indicator of Russian northern latitude concern, Soviet forces opposite northern Norway comprise no less than two motor rifle divisions and a naval infantry regiment with amphibious craft and air cushion vehicles, with seven more rifle divisions and an airborne division immediately available (Ref 4:335).

Effect of Climate. In essence, the problems of northern-latitude warfare stem from two very basic roots: climate and geography. However, these two factors manifest themselves in extremes not found in any other potential area of military

operations. Weather can vary more widely in northern latitudes than almost anywhere else in the world. The mixing of moist maritime and dry, cold polar air masses creates intense, fast-moving storms which can bring hurricane-force winds to southern coastal areas; this same mixing can produce dense fog with high winds which can persist for days. Even with clear skies, winds blowing almost incessantly across snow-covered regions can create ground blizzards which can reduce horizontal visibility to zero. Inland areas may experience weeks of fifty-below-zero temperatures and resulting dense ice fog, a phenomenon which is primarily caused by man-made sources of moisture and which can completely close airports and bring even ground movement to a near-standstill. During the summer, these same interior valleys endure numerous thunderstorms, some of which may be severe and which can occur more than a hundred miles north of the Arctic Circle.

Even though these extreme weather conditions exist only a fraction of the time, they contribute to the extreme variability of northern weather, which is itself a major planning factor. For instance, in the Aleutian Campaign, the Eleventh Air Force was able to fly an overall average of only eight combat sorties per day from mid-1942 to late 1943; moreover, its losses on combat sorties alone were 214 planes, of which no fewer than 174 were lost to weather and mechanical failure. In the same campaign, the Japanese lost 88 planes in combat and approximately 200 in fog and storms (Ref 7:370).

It is generally agreed that some of the lowest temperatures on earth occur in arctic and subarctic regions; however, it is less widely apparent to many observers how profoundly such cold can affect the operation of both men and machinery. For instance,

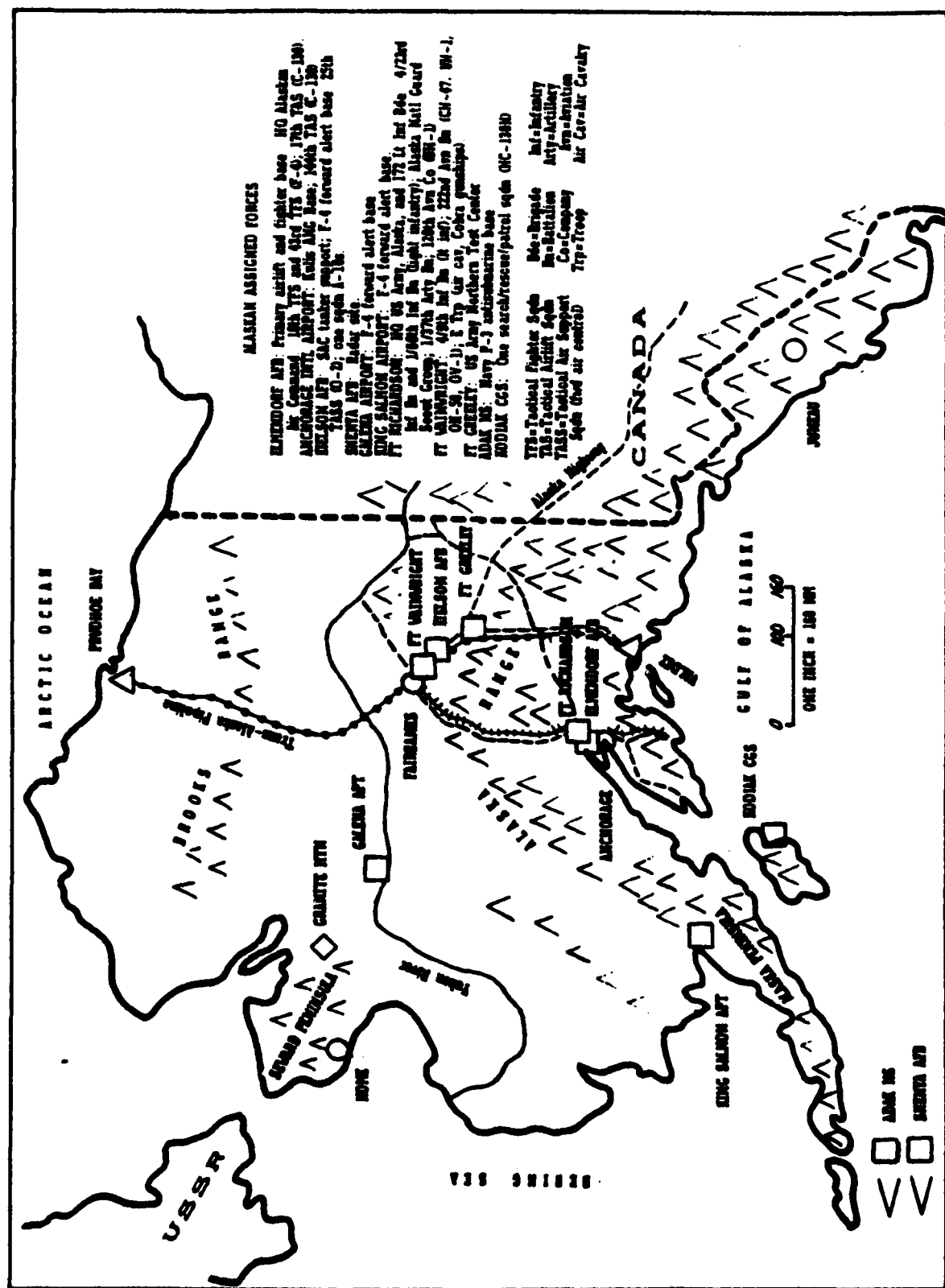
support requirements for men in the field increase dramatically. Special provisions, ranging from insulated clothing to heated latrines, must be made for all manner of common activities. Inadequate lubrication and even actual degradation of metal properties causes machinery to function less efficiently or not at all, and even special winterisation cannot guarantee the continued operation of complex modern equipment. The toll on personnel is high as well -- in one battle of the initial Russian assault on Finland in the winter of 1939, Soviet casualties were 27,500 dead, most of whom froze to death (Ref 8:1034).

Limitations of Geography. Even without the extremes of weather, geography alone would create severe difficulties for northern-area operations. A major factor is sheer distance: from Anchorage to Fairbanks is 360 road miles; from Anchorage to Nome is more than 650 miles -- with no roads; from Anchorage to Shemya, at the western tip of the Aleutian chain, is almost 1500 air miles. Distances from population centers to outlying regions in northern Canada and Siberia are even greater. Surface transportation networks are minimal in all northern regions; the highway system in Alaska goes no further west than Anchorage and Fairbanks, and the Arctic Slope Haul Road is the only highway which crosses the Arctic Circle in Alaska. Transportation systems in northern Canada and northern Russia are equally as sparse. While some river transportation is possible during the summer, and while ice roads and tractor trains may be used (with much effort) in the winter, the terrain in northern regions essentially prevents conventional large-scale off-road surface movement. Where mountains do not block ground vehicles, swamps, forests, and impassable tundra provide effective barriers to summer travel. Ground travel is somewhat easier in the winter, although the only

vehicles which can move with any speed in such conditions (snowmachines and some light tracked vehicles) have very limited cargo carrying capability. Helicopters provide a means to overcome many field mobility problems, and in fact play a major role in modern northern-region planning. However, helicopters have limited range (especially with heavy loads) and require extensive logistics support. While airmobile elements can alleviate local mobility problems, they are not a satisfactory solution to long-range movement.

Importance of Airlift. In general, climate and geography act in concert to make fielding of large forces prohibitive or nearly so in northern areas. Climate and lack of existing facilities dictate considerably increased support for any force, while distance and lack of surface transportation make such support almost totally dependent sea or air channels. Except for more southerly coastal areas (along the Gulf of Alaska, for instance) sea transport is unreliable because of ice, if not enemy action. This leaves airlift as the primary and often the only means of long-distance transportation in such areas as Alaska, northern and central Canada, Siberia, and extreme northern Europe. Accordingly, the size of forces employed in northern regions without surface transport must logically be dependent on the ability of airlift to provide reliable and sustained movement of men and supplies.

No major power has ever maintained an entire theater of operations in wartime with airlift as the sole means of intratheater transportation, and certainly no such undertaking has ever been conducted subject to the distances and operational limitations inherent in northern areas. Nevertheless, the current plans for the defense of Alaska are based entirely on such a concept, however, untried it may be.



Alaska as a Potential Battlefield

Summary of Conditions. Let us examine Alaska to see how this concept might operate. (Figure 1 is an outline map of Alaska showing key geographic, cultural, and military features.) Geographically, Alaska is fully a fifth as large as the CONUS -- almost 600,000 square miles. Excluding the southeastern panhandle, the population of less than half a million people is concentrated along the Alaska Railroad, in the so-called Railbelt between Anchorage and Fairbanks. The highway network is very limited, linking Anchorage, Fairbanks, and the oil port of Valdez with each other and with the Alaska Highway. Outside the Railbelt, population is scattered widely in villages and a few small towns, with aircraft virtually the only means of transportation.

The terrain varies widely, from heavily forested mountains along the Gulf of Alaska coast to northern birch and fir forests in the interior valleys to barren tundra on the North Slope and along the Bering Sea coast. The many mountain ranges serve to compartmentalize the geographical regions and serve as barriers not only to travel but to weather as well. Weather patterns are often quite different in adjacent geographical areas, and a flight from Anchorage to Nome, for instance, may cross through as many as four completely different weather zones. As mentioned above, these weather systems may vary from blizzard to summer thunderstorm, and can change with unexpected suddenness at any time of year.

The "Arctic Rapid Deployment Force". Military forces in Alaska are relatively few and dependent on two main base complexes: Elmendorf AFB and Fort Richardson at Anchorage, and

Fort Wainwright (formerly Ladd AFB) and Eielson AFB near Fairbanks. Air Force combat units consist of two squadrons of F-4s and one ten-plane C-130E squadron at Elmendorf AFB, an eight-plane C-130E Air National Guard squadron at Anchorage International Airport, and a squadron of O-2s for forward air control work is based at Eielson AFB. F-4 detachments from Elmendorf maintain air defense alert at Elmendorf, Eielson, Galena Airport, and King Salmon Airport, and SAC rotational detachments from the CONUS provide tanker support at Eielson. Army maneuver units in Alaska are limited to one light infantry brigade, with two battalions at Fort Richardson and one at Fort Wainwright. An Army aviation battalion with UH-1s and CH-47s is based at Fort Wainwright, with one regular and one National Guard UH-1 company at Fort Richardson. The Alaska National Guard Scouts, a largely native reconnaissance and light infantry force, comprise approximately one battalion scattered throughout the state in more than 60 small detachments.

Employment of these forces must be based on several assumptions. First, it is considered unlikely that Alaska would be the only area requiring military action, and that primary trouble areas would receive much higher priority. Thus, employment concepts assume that little or no augmentation would be available from non-Alaska sources, leaving in-theater forces to cope with the problem (Ref 4:359). Second, it is assumed that opposing forces would be of the same order of magnitude as theater forces; this is based on the belief that Soviet forces would be limited by transportation difficulties to at least the same extent as Alaskan units. It is further assumed that any Soviet buildup to support larger forces would be easily detectable and in any case would be unlikely in a worldwide crisis scenario. In

essence, the forces in Alaska comprise an "Arctic Rapid Deployment Force" not intended to deal with large enemy forces, but instead tailored to the most likely threats to the theater.

Three Alaskan Scenarios. Given that any incursion would be limited to relatively small forces (as compared to the large-scale corps- and army-size confrontations in Europe and the Far East) the possible contingency scenarios and reactions fall into three categories. First is a guerrilla/terrorist campaign of sabotage and harassment, accompanied by quick-strike missions against selected targets. Small ground units could be infiltrated by sea or air to attack isolated, vulnerable targets such as pipeline facilities or communications installations; this type of action would be largely limited to the central and southern areas of the state, where cover is good and maneuver is relatively easy for light units. Enemy air support for such a campaign would probably be limited to special-operations-type resupply, since distances from potential Soviet bases to targets in interior Alaska are too great for most strike aircraft. Reaction to this scenario would likely be limited to small-scale search-and-destroy missions by theater forces; demand on airlift resources for transportation would be moderate and reasonably continuous.

Second is a full-scale conventional incursion by up to division-size forces in western Alaska, at a location capable of air and/or sea resupply such as Nome or King Salmon. Such an incursion could imply subsequent movement toward interior targets with air support based at captured airfields, and might or might not be accompanied by a small-unit harassment campaign as described above. One reaction to this scenario might be to deal quickly with any activity in the interior but employ a defense-in-depth against the main force, letting enemy forces

contend with the great distances, inhospitable terrain, and adverse climate between coastal regions and the high-value areas of the Railbelt. This would be similar to the traditional Russian defense against invaders which has proven so effective even against modern armies. Demand for airlift transportation under this scenario would be about the same as for the harassment-campaign option, with considerably increased transportation needs as soon as the time was considered proper for a counteroffensive.

The third scenario is a conventional incursion as just described, but with immediate reaction by Alaskan ground and air forces against the main enemy force. There could be several reasons for such a reaction in force, such as the political necessity to react quickly to an overt attack on American soil. In any case, such a reaction represents the worst-case scenario in that theater forces would be denied the advantages of a defense in depth in order to assume an offensive posture. Such an offensive force would be subject to the same handicaps as the enemy force, to include increased logistics requirements, long air supply lines, limited air cover, and difficulty in mobility.

Planning and Exercise Inadequacies. Logically, the reaction-in-force scenario would place the greatest and most immediate demand on theater airlift resources and should receive the closest study. However, such study has been limited; until 1978, in fact, the reaction-in-force scenario was largely disregarded by Alaskan planners, nor did in-theater exercises address the issue. It should be pointed out that the yearly JACK FROST exercises, the primary JCS-directed exercises in Alaska, were not designed to test Alaskan employment concepts, but rather

to evaluate general cold-weather problems and capabilities. As such, JACK FROST was always conducted in the Tanana Valley near Fairbanks and the Eielson-Fort Wainwright complex, and evaluation of long-range employment capabilities of Alaskan forces was never specifically included in the exercise objectives. Emplacement of forces was strictly administrative, field play was strictly controlled and limited to small areas, and use of airlift was minimal.

Aside from JACK FROST, in-theater joint exercises were very limited in scope, rarely involving movement of more than one company. Although the distances in some of these exercises were realistic, theater airlift resources were never taxed to the extent demanded by a major reaction to the western perimeter of the state. Most Alaskan Air Command exercises were primarily designed to test air defense capabilities, and airlift involvement was limited to deployment of a few maintenance packages to forward bases. Likewise, command-post exercises were air-defense oriented, with Army moves being simulated and airlift participation limited to little more than a telephone answering service.

Development of Current Concepts. By 1978, it was apparent that movement of a substantial force from the main base complexes to the western part of the state might be necessary, and plans were adjusted accordingly. In this adjustment, extensive coordination between airlift, Army, and air defense planners resulted in a reasonably firm estimate of Army intentions in the event of a contingency. This was noteworthy in that the US Army, Alaska, committed itself to a specific concept of employment which in turn allowed Air Force planners -- and airlift planners in particular -- to make accurate estimates of support requirements

and tactics needed to insure accomplishment of the airlift mission (Ref 2).

The Army employment concept was very straightforward. As quickly as possible after the initial incursion, assault forces were to be marshalled at an intermediate airfield for an assault on a forward airhead, which in turn would be within helicopter range of the enemy force. As soon as the forward airhead was secured, it would be improved as required by airdropped earthmoving equipment; while the field was being prepared for use, ground forces would be supported by airdrops alone. Helicopters, which were to provide primary field mobility for ground forces, would move with the advance forces and would receive airdropped fuel until the airhead was open. Once open (normally within 24 hours) the forward airhead would become the central supply base, as well the jump-off point for additional forces. Refueling for airmobile elements at the forward airhead (with airlifted fuel) would obviate long trips to rear areas for fuel and supplies; this optimum use of helicopters would greatly increase the mobility and striking power of ground forces. The primary departure from previous thinking was that airlift resources would be used as much as possible in the airland role in low-threat areas, with airdrops limited to initial resupply at the forward airhead and insertion and/or resupply of isolated units in the field. Mobility of forces once in the field was assigned to integral airmobile units, while airlift was to be used to its best advantage in the low-threat airland mode. Large airdrops at or near the battle area, long a staple of Army and airlift planners, were ruled out as too costly in terms of both attrition and inefficient use of airlift resources (Ref 2).

Implications for Airlift. At the same time Army employment concepts were being crystallized, various other airlift requirements were firmly identified, with the end result that tactics and training for theater airlift forces could be optimized for accomplishment of a specific mission -- a luxury not previously enjoyed by tactical airlift forces. This required considerable reorienting of theater airlift training programs, since Alaskan units had been training for the same broad spectrum of employment as all other MAC tactical airlift units. It was found that many procedures (such as mass airdrops and low-altitude parachute extraction of equipment) were not necessary or suitable for operations in Alaska, while others which would be needed (such as special-operations-type airdrops and bulk fuel resupply) were not being practiced to the extent required, if at all (Ref 15). The end result was a training program customized for Alaskan forces; this marked a significant departure from previous MAC thinking in that theater-specific forces (as opposed to forces liable to be deployed worldwide) were allowed to become experts in their own areas and to concentrate on efficient execution of their respective theater contingency plans.

Exercise ARCTIC CIRCLE. By early 1980, the new concepts of Army employment had been refined by planning sessions and "greaseboard" simulations in command post exercises to the point that a large field exercise was appropriate. This exercise developed into ARCTIC CIRCLE 80, conducted in April 1980. It was the first Alaskan exercise specifically designed to move a battalion-sized force from the Railbelt area to the western perimeter of Alaska, a distance of more than 600 miles. Unlike previous exercises in the theater, the sole objective of ARCTIC CIRCLE was to move a battalion to the western perimeter

(simulating a attack on Nome) via a bare-base forward airhead with complete supply of ground and airmobile forces by airlift (Ref 23). The actual move from Railbelt to striking position took three days, and although the operation was a success, it pointed out that there were many factors yet to be examined (Ref 2). Even with the success of ARCTIC CIRCLE 80, only a small part of the theater contingency airlift system has been tested, and even then with relatively favorable weather under controlled peacetime conditions. For instance, the entire wartime scenario might simultaneously include not one but two or three battalion moves, as well as resupply for forward fighter bases and a heavy non-combat logistics tasking. Moreover, a contingency might last for weeks or months, and supplies from the CONUS might be limited or late in arriving. Since the system was built largely piecemeal as various requirements appeared, the projected ability of the Alaskan airlift system to cope with an actual contingency rests on a relatively limited and largely theoretical foundation. The system as it now exists has never been examined from an overall, long-term aspect, and recent discussions with Alaskan airlift planners and with their counterparts at the Military Airlift Command indicate that no such evaluation is contemplated, although recent exercises such as BRIM FROST 81 have paid much more attention to the airlift role.

Problem Statement

Given that airlift is a vital factor in any defense of Alaska, the first part of the problem is that an overall analysis of the wartime operation of the theater airlift system needs to be undertaken. Such an analysis could be obtained by actual

full-scale execution of the theater contingency plan. Even for a theater with forces as limited as in Alaska, however, such execution would be prohibitively expensive and would consume difficult-to-replace resources, and could additionally compromise the plan itself. Another approach could be to conduct several separate, smaller exercises, each testing various parts of the system. This, in fact, is what is being done, but cost constraints and a substantial day-to-day operational mission severely limit size and frequency of exercises, while peacetime operating restrictions dictate much decreased realism. Also, such piecemeal testing cannot evaluate interactions among system components, which could be a major factor in actual wartime operation. Moreover, multiple actual executions or series of exercises would be required to assess the effects of different climatic conditions, which in turn could vary widely depending on both season and actual battle area location (Ref 2).

Basis for an Alaskan Airlift Model. One feasible method for an overall analysis of the Alaskan airlift system (or of any such airlift system) would be construction and use of a computer simulation model. (Reference 20 provides an excellent outline of advantages and drawbacks of models in this type of application.) Use of an existing model might be convenient, but no suitable models exist. The MAC M-14 model is designed exclusively for strategic (intertheater) airlift (Refs 8 and 11). The MAC Tactical Airlift Model (TAM), a development of the Air War College's Theater Airlift in the (Central) European Theater (TACET) model, is almost ready for use, but does not satisfactorily examine several factors which would be of prime interest in Alaska, such as risk, attrition, and certain forward base limitations. Additionally, the TACET/TAM model is based

primarily on a central European scenario, which does not envision long-distance mass movement of forces by air to an austere forward airhead (Ref 21). Some older intratheater airlift models are available, but likewise do not satisfactorily treat factors which would most likely drive Alaskan operations (Ref 5). This points out a fact which underlies the modeling of theater logistics systems (including airlift) -- no two theaters are alike, and a model which accurately reflects one may be totally inappropriate for another.

Although it might be possible to create a model which would examine every aspect of Alaskan airlift, such a model would require considerable resources -- the MAC M-14 model, for example, took more than three years to construct and is not yet fully operational (Ref 8). Fortunately, the original TACET model can provide a conceptual framework for construction of a specialized Alaskan model. As mentioned, however, TACET does not address some factors which would be of interest in Alaska, and further includes some aspects which would not be applicable in Alaska (Ref 8). Additionally, a full-scale adaptation of TACET would be in many respects too detailed for a time-constrained first look at an essentially untried theater airlift concept. Therefore, a scaled-down model incorporating some features of TACET would seem to be a feasible avenue of approach to the problem of analyzing Alaskan theater airlift.

Summary. The remainder of this thesis will discuss the conceptualization, development, and application of an Alaskan theater airlift model. Chapter II will examine the Alaskan airlift network from a systems approach and will outline the conceptualization of the model. System boundaries, functional organization, and operational "flow" will receive particular

attention. Chapter III will identify the major components of the system and discuss the assumptions and limitations which were required to incorporate these components into the model. Chapter IV will describe the actual computerization of the model; selection of the simulation language will be discussed and model structure and special features will be outlined. Chapter V will cover the verification and validation of the model and will briefly examine a few of the problems encountered in this area. Chapter VI illustrates the use of the model for analysis. A representative scenario is constructed and a screening experiment is executed to identify factors which significantly affect system performance. The two most important of these are then analysed and conclusions drawn about their effects and interactions. Lastly, Chapter VII offers conclusions and recommendations based on the model and the analysis.

II. Conceptualisation

This chapter will examine the Alaskan airlift network from a systems viewpoint. First, the system will be described and the influences acting upon it will be identified. The system will then be broken down into its functional components, which will be individually examined. Finally, system operation will be illustrated by following an aircrew through a typical crew duty day in a wartime scenario.

System Description

Following the TACET framework, the first step in developing a model should be to describe the system to be simulated, as well as identify associated constraints, inputs, interactions with external systems, and measures of system effectiveness. TACET defines the functional bounds of an intratheater airlift system as "all of the ground, flying, and decision activities performed in direct support of the tactical airlift mission," a definition which is appropriate to Alaska as well as Europe (Ref 20:IV-11).

Theater Influences and System Boundaries

As in Europe, the Alaskan airlift system reflects the theater in which it is located. Unlike Europe, the Alaskan logistics and communications networks are highly centralized, with a single major urban center (Anchorage) which provides almost all goods and services to the remainder of the theater. Anchorage is both the major point of entry for goods from outside the theater and the major point of origin for distribution of goods within the theater, and is additionally the center of the theater communications network. The two major military installations in

the state are also located at Anchorage (Elmendorf AFB and Fort Richardson). Although there is a secondary urban and military center at Fairbanks, the Fairbanks complex serves primarily as an intratheater transshipment and distribution point.

In general, then, virtually all external inputs to the Alaskan theater are funneled through Anchorage, and from a theater viewpoint almost all intratheater movements can be considered to begin there. It is important to note that some external inputs can and do enter the theater at Fairbanks; however, the means to move these inputs to theater destinations are usually based at or in some way dependent on the Anchorage complex. In any case, intertheater transportation systems such as oceangoing container ships or strategic airlift aircraft are rarely used for (and are usually unsuited for) intratheater movement.

The high degree of centralization of the Alaskan theater allows the theater airlift system to operate almost completely free from non-theater interactions, since inputs from "Outside" need only be reflected as constraints or inputs upon the Anchorage complex. (Relatively little cargo originates in Alaska for "Outside" destinations except for crude oil from the pipeline terminus of Valdez and timber and raw materials from the Southeastern area; neither of these outward flows affects the central Alaskan logistics system.) As far as the Alaskan military airlift network is concerned, all crews, maintenance activities, and major aerial port facilities are located at Anchorage, and all missions are dispatched from and must ultimately return there, even though some missions may begin and/or end elsewhere in the theater. Other bases and airports in the theater are viewed strictly as transient bases with no maintenance, fuel, or crew rest facilities and with limited cargo handling and traffic flow characteristics.

The "movers" in this system are theater airlift aircraft, which in Alaska are exclusively C-130E Hercules aircraft. The items moved are individual aircraft loads of various general types (called "chalks" or "missions") which are presized to meet C-130 limitations. Missions become available for movement at specific times and may originate or terminate at any base within the system. A mission must be "picked up" at its originating location and is not considered complete until it has been offloaded at its destination (or last destination, if a multiple-leg mission), at which time it is no longer a factor in the system. An aircraft can handle only one chalk or mission at a time and must follow the prescribed itinerary of its assigned mission until the mission is complete or is temporarily terminated due to an abort or other unanticipated development.

On arrival at a base, an aircraft must land, taxi to parking, and offload (if required). If at home base, the aircraft must then undergo maintenance checks and refueling. At all locations, the mission is then checked for completion: if complete, an attempt is made to schedule another mission; if not complete, scheduling is not attempted. After mission completion check and/or scheduling, the aircraft must then onload (if required), taxi out, and take off. After departing a base, the aircraft proceeds to its next destination; enroute, it is subject to weather, threat, and mechanical considerations. If adverse conditions are encountered, the aircraft may be aborted to home base and its assigned mission removed and made available for other aircraft. On arrival in the vicinity of its destination, the aircraft executes an approach and enters the destination base sequence of events as as described above.

Causal Relationships. The primary output of the system is completed missions, which in turn reflects various measures such as tonnage airlifted, Army units moved, etc. Execution and completion of missions depends directly on availability of aircraft to fly them. For a given series of missions and conditions, fewer aircraft available logically means fewer missions completed in a set period of time, or (as is the case in practice) a longer time to complete all required missions. Aircraft availability, in turn, is dependent on actual numbers of aircraft, number of crews, and maintenance capability. Fewer aircraft or crews or decreased maintenance capability would lead to fewer aircraft available and thus to a degradation of mission completion capability. Given aircraft available, the ability to complete missions is affected at individual locations by cargo-handling capability, available ramp space, and traffic flow limitations resulting from physical airfield considerations (number of aircraft on approach, number of runways, etc.).

Enroute, aircraft movement and thus mission completion are affected by weather, threat, and mechanical problems, which may cause an aircraft to abort or even to be lost. Also, and particularly in Alaska, distance between bases plays a large factor in aircraft operation. Various factors are affected by season: winter means cold temperatures, which generally cause longer service times for cargo handling and maintenance, which in turn degrade mission completion. Colder temperatures also affect aircraft operation directly, in that longer warmup times are required and maintenance problems can increase in number. Season also affects weather, with winter bringing more periods of lower ceilings and fog, which in turn result in mission delays and aborts. Bad weather also affects threat by creating conditions in

which airlift aircraft cannot effectively use concealment tactics; if threat is too high, missions either are not attempted or must face enroute attrition, with resulting negative impact on mission completion. The accompanying causal loop diagram (Figure 2) outlines these relationships.

Sortie Phases

The TACET model defines three activity phases for each airfield: arrival, ground, and departure; the arrival phase also handles the enroute function of transferring aircraft from base to base. In the course of transiting these three phases, the aircraft is run through an entire sortie sequence. In the Alaskan model, the three TACET phases need to be modified to reflect the natural flow of the system; additionally, to better break out threat and weather functions handling in the TACET arrival phase, a fourth phase must be added for enroute activities. (Ref 20:IV-21).

For the Alaskan model, the ground and departure phases can be redefined to more accurately divide inbound (offload, maintenance, refueling), dispatch (mission completion check and scheduling), and departure (onload) activities. With the inclusion of the separate enroute phase, an aircraft in the Alaskan system would pass through Departure, Enroute/Approach, Arrival, and Continuation/Scheduling phases in the course of a sortie from one base to the next. (A single mission, of course, might require more than one sortie.) Figure 3 outlines these phases and what each encompasses.

Departure Phase. This phase begins as soon as an aircraft has finished offloading and has been either scheduled for a new mission or prepared to continue its current mission. If at home

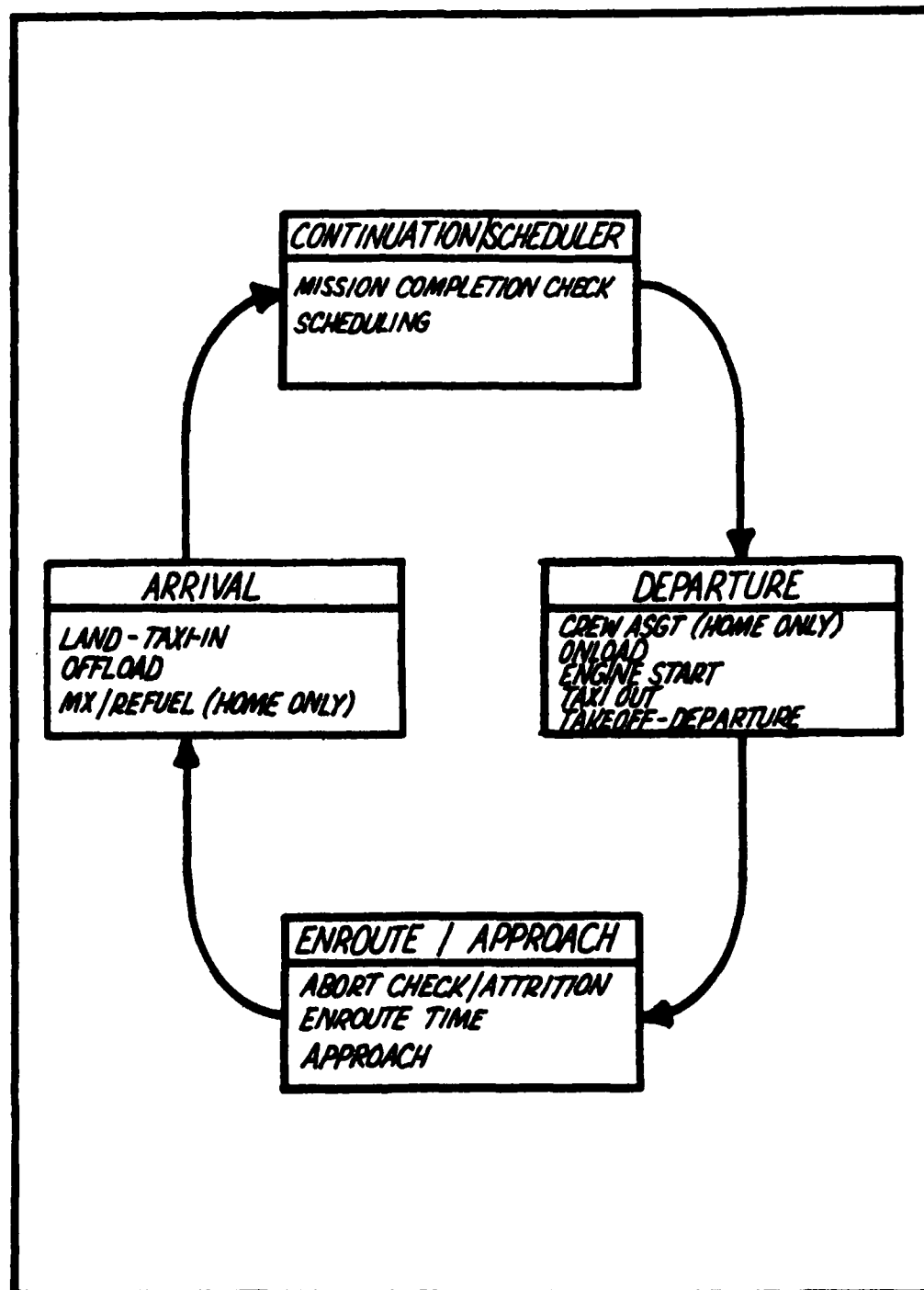


Figure 3: Sortie Phases

base and the aircraft has just been assigned a new mission, and if the new mission cannot be completed within the remaining crew duty day of the present crew, the aircraft must be paired with a rested crew before beginning onload; crew changes are not accomplished at enroute bases. Next, the cargo (if any) for the current leg of the assigned mission is unloaded. The aircraft then starts engines if it has been on the ground long enough to have required that engines be shut down. On engine start, the aircraft is subject to maintenance malfunctions which may result in delay, abort, or grounding. If engine start is successfully completed, the aircraft taxis out and takes off. If at a base with traffic limitations, another aircraft may be on approach/taxi-in or taxi-out/takeoff; if so, the departing aircraft may be forced to wait before taxiing and/or taking off. After takeoff, the aircraft must depart the local area before entering the enroute phase.

Enroute/Approach Phase. When takeoff and departure are completed, the aircraft enters the enroute phase, which takes it up to final approach and landing at its destination. In this phase, the aircraft is assigned an enroute flying time and is subject to abort from mechanical failure, unforecast weather, or increased (and unacceptable) risk. If conditions so dictate, the aircraft also undergoes a risk of attrition: different combinations of weather, threat, and escort availability produce various levels of risk, which in turn govern attrition rates. In extreme cases, an aircraft can be lost to the system in this way, along with its crew and cargo. If aborted, the aircraft remains in the enroute phase but is automatically directed back to home base, with an appropriate enroute time assigned. The enroute phase also covers arrival in the destination area: if the

destination base has an approach suitable to the weather conditions, or if the weather is VFR, the aircraft is permitted to make a successful approach. If the weather is below minimums, the aircraft may or may not be allowed to try the approach with the hope of "breaking out" in time to land. If unsuccessful, the aircraft is aborted to home base (remaining in the enroute phase). Once an approach is successful, the aircraft proceeds to the arrival phase.

Arrival Phase. After beginning a successful approach, the aircraft completes the approach, lands, and taxis in. At bases with traffic limitations or with limited ground space (maximum number of aircraft on the ground, or MOG), the inbound aircraft may have to wait for an aircraft on the ground to depart; this holding would be conducted in the immediate vicinity of the destination base. Once parked, the aircraft is unloaded (if required); engines are kept running unless ground time is anticipated to be long enough to require shutdown. If at home base, the aircraft then undergoes maintenance, consisting of mandatory minor maintenance and any required repairs to major systems; following maintenance, the aircraft is refueled. After offloading and/or maintenance, the aircraft proceeds to the continuation/scheduler phase.

Continuation/Scheduler Phase. Before proceeding to the departure phase, the aircraft is checked to determine if it has completed its current mission. If the mission is not complete (i.e., more sorties or "legs" are required), the aircraft is configured to reflect requirements for its next leg and then sent on to the departure phase. If not at home base, the aircraft is also subject to maintenance problems which might have occurred during approach, landing, or engine shutdown (if required); these

problems may require that the aircraft abort to home base or be grounded at its current location, or more probably will simply delay the aircraft's entry into the departure phase. (These enroute maintenance problems would normally not prevent offload, but would affect mission continuation or rescheduling; therefore, they need not be taken into account until the continuation check.) If an aircraft has completed its mission, it is ready to take on another mission, as determined by the scheduling function. If a mission is scheduled, the aircraft proceeds to the departure base. If not at home base and no mission can be scheduled, the aircraft is routed directly to home base; if at home base, the aircraft is held until a mission becomes available.

System Operation

Perhaps the operation and limits of the Alaskan airlift system can best be illustrated by following an aircrew through a sample 18-hour crew duty day, as shown in Figure 4. It is important to note that this will show operation in a wartime scenario; some of the procedures and techniques mentioned are commonly used in "high-flow" situations and can often substantially improve ground and enroute times over "standard" times. (The duty day illustrated is similar to one which the author actually executed during ARCTIC CIRCLE 80 and is typical of what would be expected in support of a major Army move to western Alaska in wartime.)

Typical Mission. At Elmendorf at 0800, a fresh crew arrives at the aircraft to supervise the loading of an Army chalk bound for Granite Mountain Airport (an austere forward airhead 800 miles northwest of Anchorage); the chalk consists of 15 troops and personal equipment, a "GAMA COAT" (articulated six-wheeled Army

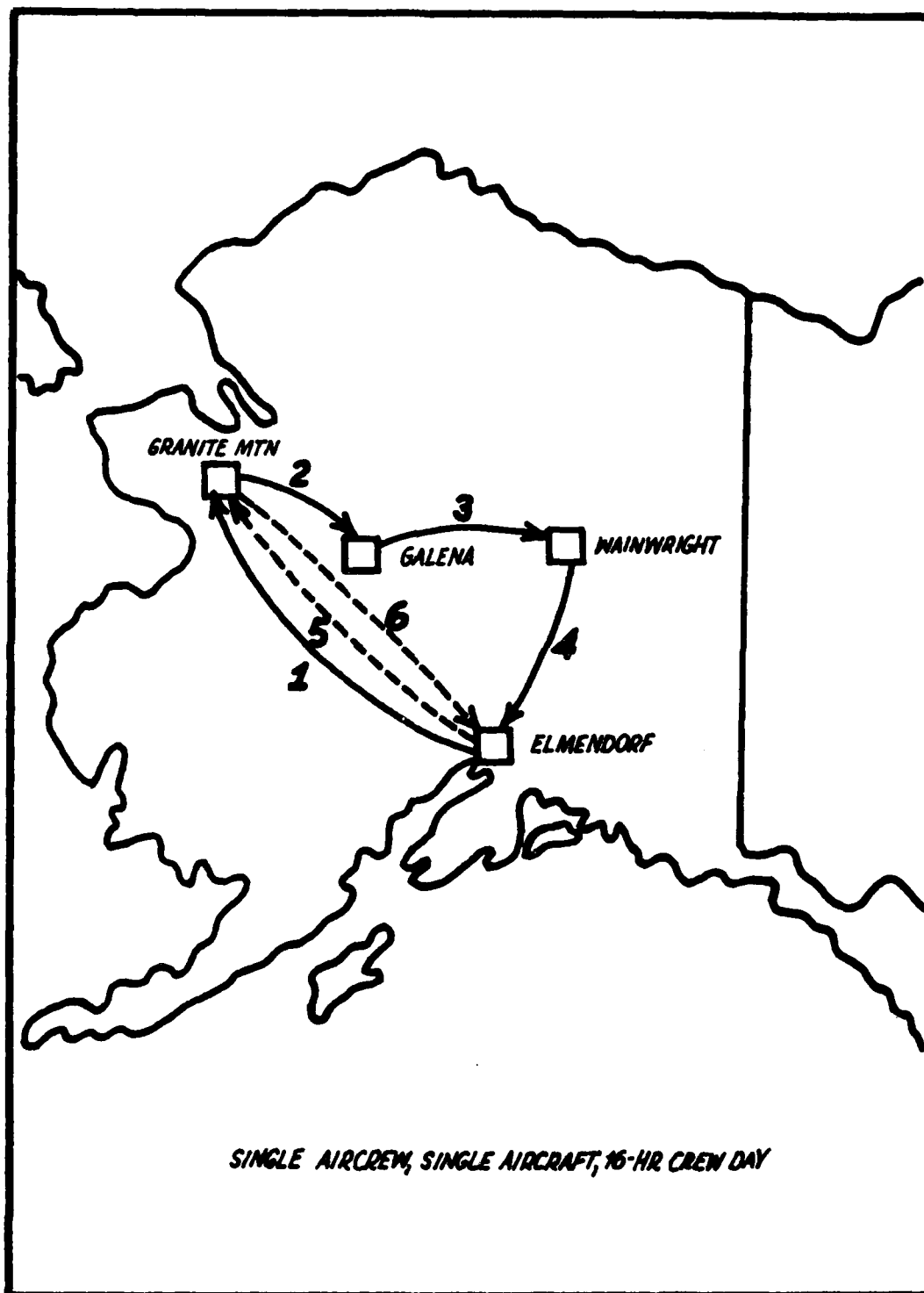


Figure 4: Typical Alaskan Airlift Mission

all-terrain truck), and miscellaneous non-palletized equipment. With the help of Aerial Port load teams, the onload takes less than a half hour. Engine start and warmup take another ten minutes; minimum delay is experienced on taxi-out and departure and the aircraft is airborne and out of the Anchorage area by 0700. After crossing the Alaska Range and about halfway to Granite Mountain, the crew descends to 300 feet above the ground to begin low-level terrain-following tactics; this is necessary because enemy fighter activity is possible in Western Alaska and escort will not be available for this mission. Fortunately, the weather is middle-level overcast, which provides near-perfect cover for the unarmed airlift aircraft while still allowing full employment of terrain-following tactics. Following a preplanned low-level corridor which avoids known and suspected enemy ground forces, the crew makes good a planned arrival time of 0930 overhead Granite Mountain. However, there are already two aircraft on the ground and no space for another aircraft, so the inbound crew orbits at low level a few miles from the field until one of the aircraft on the ground takes off. After landing at 1005 on the partially snow-covered gravel runway, the crew must turn around and back-taxi down the runway to the small offload area. While taxiing, the loadmaster opens the ramp and door to expedite offload and begins to remove the tiedown chains from the vehicle. As the aircraft pulls into the parking area at 1010, the GAMA GOAT is started and the troops have their gear in hand; when the aircraft is finally stopped, engines are left running since ground time is expected to be very short. As the aircraft stops, the last tiedown chain is removed from the vehicle, the cargo ramp is lowered to the ground, and the vehicle is driven off. The troops offload their personal equipment and then return to assist

the loadmaster in removing the thousand pounds of miscellaneous equipment (ammunition, radios, and food); the offload is completed at 1020, having taken only ten minutes.

During the offload, the crew is advised of its next mission by the forward-base aerial port load team: there are several Army personnel who must return to Galena Airport (being used as an Army helicopter staging base) and two pallets of damaged helicopter support equipment to return to Wainwright AAF (at Fairbanks). The returning Army personnel board immediately and the pallets are loaded one at a time with an all-terrain forklift after the inbound load is offloaded. The return load is on board by 1040 and the pilot taxis to the end of the runway for takeoff; engines were never shut down during the 30 minutes in the parking area, thus saving 10 to 15 minutes on departure. By 1050, the crew is out of the Granite Mountain area enroute to Galena, flying low-level until out of the possible enemy threat area. Arriving at Galena at 1150, the pilot executes a straight-in VFR approach and taxis directly to the parking area. The passenger-only offload takes only a few minutes and the aircraft is airborne again by 1205 enroute to Wainwright. Since there is no threat in this area, the flight to the Fairbanks area can be conducted at normal altitudes (15000 to 25000 feet). Arriving at Wainwright at 1310, the pilot is able to make a no-delay approach and landing thanks to Wainwright's twin runways; offload is completed by 1330.

While offloading at Wainwright, the engineer notices that number three engine has lost considerable oil; after shutting down the engine and performing a quick inspection, the problem is diagnosed as a worn oil line which should be replaced. Since there are no maintenance facilities in the Fairbanks area capable of dealing with the problem, the aircraft commander and the

engineer decide that the leaking oil line will permit safe flight back to Elmendorf. Since there are no loads at Wainwright bound for Elmendorf, the aircraft departs empty for home at 1345.

Before departing Wainwright, the pilot advises the Elmendorf command post of the maintenance problem and his intentions; the controller at Elmendorf agrees with the plan and advises maintenance personnel, who meet the inbound aircraft on arrival at 1445 and begin work immediately to replace the faulty line. As soon as the oil line is replaced and several minor problems are corrected, the aircraft is refueled, with the entire maintenance/refueling process complete at 1530.

The next mission is another Army chalk for Granite Mountain, this time consisting of 30 troops and personal equipment, plus one pallet of ammunition. The troops, cargo, and a load team with forklift are at the aircraft by the time maintenance is finished, ready to begin loading. Since the projected mission duration (outbound and subsequent return to Elmendorf) is only about six hours, the crew should be able to return home before the end of its 18-hour crew day at 2200; thus, a new crew is not required. The loading is complete at 1530, engines are started without incident, and the aircraft is airborne by 1615.

The aircraft lands at Granite Mountain at 1845 with no delay, and the offload is complete at 1900. There are no loads at Granite Mountain for Elmendorf, and since the crew does not have sufficient crew day left to begin a mission for any other base, the aircraft departs empty for home at 1905. The crew finally leaves the airplane at Elmendorf after shutting down engines at 2150, ten minutes short of a 18-hour crew day. Enroute to begin their 12-hour crew rest, the old crew meets the aircraft's new crew at the command post; the old crew quickly briefs the new crew

on enroute conditions and on the aircraft status, thus allowing the new crew to take the aircraft without a time-consuming full preflight inspection. The retiring crew then departs for crew rest.

With minor alterations in load and destination, this scenario is repeated until all missions are completed. As can be seen, the Alaskan theater airlift system operates largely on a "line-of-sight" scheduling basis during a major move, with missions being assigned to aircraft as they become available, and with mission execution being dependent almost completely on well defined factors within the system itself.

Summary

This chapter has outlined the conceptualization of the Alaskan airlift system. The system is basically independent of outside interactions and can be visualized as a closed network through which aircraft carrying missions can circulate. This circulation can be viewed as a four-phase cycle, with each phase representing a functional division of the system. In order to move from one base to another, an aircraft passes through each of the four phases in a prescribed sequence. The next chapter will treat the breakdown of the system into its components, and will discuss the assumptions and limitations which were necessary to fit these components into the context of the simulation model.

III. Assumptions and Limitations

Inputs, Constraints, and Interactions

Having examined system operation, it is necessary to more closely look at the various factors affecting the system with regard to their incorporation in a model. These factors fall into three major categories: inputs, constraints, and interactions. In the Alaskan system, Alaskan system, inputs are airlift mission requirements (reflected in number and type of missions to be performed). Constraints constitute the "built-in" factors which serve to limit system performance. Some constraints may take the form of fixed parameters, such as distance between bases, while others may be variable to some degree, such as cargo handling capability at forward bases, while others, such as crews and aircraft, may be very much controllable. For the Alaskan system, constraints are airlift aircraft, aircrews, available theater airfields (and their individual physical limitations), ground support (e.g., maintenance and cargo handling capability), theater geography, weather, and threat (a combination of weather, enemy action, and escort availability). As discussed in the previous chapter, the Alaskan airlift system has few interactions with other systems or external factors because of the relative isolation and self-sufficiency of the theater. Where these interactions cannot be disregarded or viewed as inputs, they have been included as constraints; examples include fighter availability for escort and ramp space available for airlift at forward fighter bases. This chapter will examine each of the major inputs and constraints and the assumptions and limitations required to incorporate each into a simulation model framework.

Theater Airlift Requirements

In a wartime Alaskan scenario, airlift requirements for the first week to two weeks of operation have been reasonably well identified. Although the actual figures are classified, the general nature of airlift missions to be performed is not. The most immediate missions would consist of deployment of Air Force fighter maintenance support packages to forward fighter alert bases in anticipation of increased fighter activity; another series of missions would involve resupply by airdrop of the widely scattered Alaska Army National Guard Scout units in the western part of the state. Regular logistics missions in support of the Ground Controlled Intercept (GCI) radar station network could be expected to continue at their normal rate (once or twice weekly to each site) and perhaps to increase if some of the 13 stations had been damaged in an initial attack.

Within a short time (as soon as two to three days) Army moves from the Railbelt to the incursion area would begin. The mission sequences for such moves could be expected to follow the general pattern of the ARCTIC CIRCLE 80 exercise, which required more than one hundred missions to move a battalion into helicopter striking distance of an enemy on the west coast. The time required to complete a one-battalion move could be as little as a few days (based on ARCTIC CIRCLE 80) or more than a week (Ref 2). If a second battalion were to be moved to the field immediately after the first, the airlift requirement would increase even more, since resupply missions for the first battalion would then be needed. If all three battalions were to be moved as quickly as possible, the airlift load might exceed 400 missions in the first two weeks of wartime operation (a mission equals one load or series of loads picked up and delivered, and may involve several sorties; each

sortie is one takeoff and one landing). Another source of missions could be fuel resupply to forward fighter bases, should their fuel storage capability be affected; such resupply requires that one or more C-130s be dedicated indefinitely to a continuous fuel shuttle. There is a possibility that such a fuel shuttle might be needed for Army forces as well under some conditions (Ref 2).

Return loads to the main bases are generally a function of the outbound mission flow, and consist largely of empty pallets, equipment for repair, and personnel; these can be estimated based on past experience. The major inbound mission load would be the redeployment of forces to the main bases after the incursion has been dealt with.

Mission/Load Integrity. Although some missions would be of an emergency or quick-reaction nature, most outbound loads would be in support of major Army movements or pre-identified Air Force needs. Loads for these known requirements have been well identified and have been pre-sized and planned for movement by C-130. Although it would be expected that some of these loads would be "broken" and that the advance loading plans would not always be adhered to, model simplicity requires that loads be regarded as integral units. In this way, loads can be treated as individual entities to be moved through the system and the complex process of load construction and breakdown need not be modeled. The relatively few emergency or unplanned requirements would be estimated and included in the overall mission input.

Each mission would thus represent a pre-sized C-130 load (or "chalk", when referring to Army loads) which is available for onload at a specific base at or after a given "ready" time. Once onloaded, the load must be delivered through the system to its

specified destination or destinations; once delivered, the mission is complete and can be removed from the system. For purposes of tracking mission completion, each load/mission can be identified by a unique mission number.

Load Types. The types of loads which could be expected to be moved in Alaska (or in any C-130-oriented theater airlift system) can be broken into two general classes -- loads requiring materials handling equipment (MHE) and loads which do not. The primary loads requiring MHE (forklifts or K-loaders) are those involving various amounts of palletized cargo, which could include food, ammunition, fuel, or general supplies. MHE is invariably required to load palletized cargo onto C-130s, and MHE greatly speeds the offload of such cargo. For Alaska, loads needing MHE can be simplified into two groups: full and partial palletized loads. Full palletized loads consist of four or five pallets, while partial loads consist of three or fewer pallets and other cargo which is non-palletized (and thus occupy MHE for a shorter period of time); the difference between the two is simply one of time required for onload and offload.

Unlike many other airlift aircraft, C-130s can offload palletized cargo without MHE; this procedure is known as combat offload and consists of little more than sliding pallets down the aircraft cargo ramp directly onto the ground behind the airplane. However, combat offloaded pallets take up ramp space (which is sometimes scarce) and must be dismantled on the spot or dragged clear by trucks or other vehicles. Thus, although the aircraft can depart, ramp space is still blocked by the offloaded cargo. Additionally, combat offload involves some risk to the cargo under certain conditions, and in any case the standard cargo pallets normally used are prone to damage. Since these pallets must be

reused, and since combat offloaded cargo blocks valuable ramp space and is often difficult to remove quickly, the combat offload procedure would be used in Alaska only as a last resort at locations where MHE is normally available.

A great many loads in Alaska would not require MHE either for onloading or offloading. These loads include passengers, rolling stock, snowmachines and sleds, and non-rolling cargo which can be "manhandled". These non-MHE loads can be lumped together in terms of time needed for onload/offload. There are exceptions, of course, but these are primarily in onload times -- such as backing a GAMA COAT and 1-1/2 ton trailer up an icy cargo ramp with an inexperienced driver. Most non-MHE loads, however, have consistently short offload times -- the GAMA COAT and trailer which was so difficult to back onto the aircraft can be driven straight off in a matter of seconds at the forward base. Since most time problems are expected to occur at forward bases with limited facilities, and since loads such as the GAMA COAT would not normally be unloaded at these locations during the major outward push, non-MHE loads can be safely aggregated. (As an additional factor, treatment of all possible non-MHE load combinations would present an almost insuperable problem in terms of model complexity.)

Load Times. Actual load times in Alaska have never been documented, although most persons with operational experience in the theater can give good estimates. In summer, these times do not vary much from worldwide "standard" load times, but in winter they are considerably longer, particularly at forward locations. As a baseline, the MAC Airlift Center (ALCENT) at Pope AFB has done extensive studies on time required to perform various basic activities involving MHE under carefully measured conditions. A

single pallet offload with a forklift, for instance takes about seven minutes, while an onload would need about ten minutes (Ref 10). No formal figures are available for non-MHE activities, but these can readily be estimated. For Alaska, available "standard" figures can be used as a basis for non-winter activities; since distributions of these times are not available, and since expected minimum, and maximum times can be fairly easily estimated, triangular distributions are assumed. Since winter and cold weather would most directly affect operations at austere forward bases, winter cargo-handling times at these locations can be approximately doubled.

Airdrops. Airdrops play an important role in Alaska, and several assumptions are required for their inclusion in the model. First, formation airdrops would require a substantial increase in complexity; therefore, airdrops are assumed to be single-ship only. This is acceptable for an Alaskan model, since most airdrops would be either single-ship or small-element missions (Ref 13); in any case, airdrop priorities can easily be set to insure simultaneous or nearly simultaneous scheduling of a group of related missions. Second, only two types of loads are permitted: cargo (including all types of equipment drops which require MHE for onload), and personnel (which do not require MHE). Load times for both types are equal and include extra time for necessary briefings and for the more complicated loading procedures. Third, airdrops are not allowed to onload at bare-base forward locations or at GCI sites, and conversely are not allowed to be executed at other than those locations. (There would normally be no need to onload airdrops at forward bases in any case, nor would there be any need for airdrops in rear areas.) All airdrops in forward zones can be represented by airdrops at

the appropriate forward base, since airdrops are not subject to MOC or traffic limitations and thus will not be affected by aircraft landing at these locations. (Airdrop missions effectively bypass the arrival and departure phases of destination bases.) Lastly, all airdrop aircraft must return to Elmendorf on completion of their airdrops; although primarily for model simplification, this is often the case in practice, since most airdrops originate at Elmendorf and since special airdrop equipment must be returned for recycling.

Priority and Risk. As in any system where the number of items to be moved can exceed the capability to move them, some form of prioritization is required. In Alaska this is especially important, since the sequence in which Army chinks are moved can be critical. (For instance, the model must see that the missions carrying MHE to a bare-base forward airhead are completed before follow-on all-cargo missions attempt to land there.) Priority can be represented by a single priority number assigned to each mission before it is input. Ties among missions of the same priority can be broken by earliest ready time. This is a reasonable representation of the normal Air Force airlift priority system, and follows very closely the actual practice used in Alaska during exercises. Additionally, if threat is to be considered, missions must be assigned an "acceptable risk level", which represents the risk of loss beyond which the mission will not be undertaken. (For instance, the airdrop missions needed to secure a forward airhead may need to be flown at all costs, while normal resupply missions to GCI stations may not justify any risk at all.) Although the Air Force has no formal system to identify risk in this manner, assignment of risk levels to missions is an attempt to model the "de facto" process used by most planners and schedulers in such situations.

Aircraft Limitations. Airlift missions in Alaska can be broken into administrative and tactical classes based on mission itinerary and aircraft capability required. Administrative missions are those which do not transit a threat area and which do not require low-level flight, assault landings/takeoffs, or airdrops. These are generally "milk runs" in rear areas which are required for routine theater logistics support, and can be flown by aircraft in a degraded, non-tactical status. Tactical missions, on the other hand, require fully mission-capable aircraft and can be usually be expected to encounter a threat environment of some sort. Although there are, of course, as many possible levels of aircraft capability as there are items on the Minimum Equipment List, it is convenient for modeling purposes to use only the tactical vs non-tactical distinction. It should be noted that this is a departure from the normal Air Force use of the terms "fully mission capable" (FMC) and "partially mission capable" (PMC). In practice, almost all C-130s in Alaska are routinely FMC for one or more inoperative or degraded systems, even though these systems are frequently not required for tactical missions. Thus, "real-life" use of FMC and PMC has become nearly meaningless; the author will, therefore, use these terms to represent "tactical mission capable" and "non-tactical mission capable" exclusively. (Tactically capable aircraft can, of course, fly any mission.) Most missions in Alaska which can be accomplished by non-tactical aircraft can easily be identified, and so mission input to the model can be expected to reflect this requirement.

Summary of Mission Assumptions. Airlift requirements in the Alaskan system, then, can be represented by missions whose progress can be tracked through the system and whose completion

can be readily identified. These missions have ready times, aircraft capability required, priorities, risk levels, and individual mission numbers. Each mission also has an itinerary consisting of an originating base and one or more destination bases (to be transited in sequence). Lastly, each mission specifies what type of load is to be unloaded and/or offloaded at each stop along its itinerary.

Airlift Aircraft and Aircrews

Aircraft Types. The primary military airlift aircraft in the Alaskan Theater is the C-130 Hercules, which is flown by all currently assigned theater airlift units. Additionally, any airlift augmentation to Alaska by CONUS forces would be by C-130 units only. Although intertheater airlift aircraft (C-141s and C-5s) might be used to move cargo into the main bases in the Anchorage and Fairbanks areas, these strategic airlift aircraft are not suited for intratheater work and in any case would be of much greater value in their strategic role. The wartime Alaskan airlift fleet would also include Civil Reserve Air Fleet (CRAF) aircraft, which are pre-identified civilian aircraft which would come under Air Force control in a national emergency. The CRAF contribution to Alaskan wartime airlift is relatively minor and could be assumed to operate completely independently of military airlift. CRAF capability would remain reasonably constant and would be dedicated exclusively to non-tactical missions. Accordingly, CRAF operations need not be modeled and CRAF missions can be deducted from the overall airlift requirement before its input into the military airlift model.

Even with only C-130 aircraft in the system, some assumptions must still be made. First, it can safely be postulated that the

Alaskan theater would receive sufficient warning to generate all aircraft prior to "zero hour". Additionally, it is assumed that any augmentation aircraft from the CONUS would be in place prior to the start of the mission flow. Thus, all aircraft for model use are considered to be available in FMC status at the beginning of the simulation. (Since Alaska is assumed to be "on its own", a model realistically should not consider augmentation or replenishment of lost aircraft or crews.)

C-130 Model Interoperability. There are sufficient differences between various models of C-130s (between the C-130A and all other versions in particular) to prevent full interchangeability of aircraft, crews, and parts; some possible augmenting CONUS units still operate the C-130A. However, exercises such as JACK FROST and BRIM FROST in Alaska have shown that this problem need not be significant. In practice, only pilots and engineers would need to be restricted to their particular model aircraft; even then, many "A-model" pilots have experience in other types, and some "other types" pilots (such as the author) have experience in "A-models". In wartime, it is reasonable to expect that more than a few pilots and engineers could quickly become "dual qualified" if the need arose. It can also be expected that this process would be duplicated by maintenance personnel, for whom the distinctions between types are less critical.

In addition to being "dual qualified" if required, aircrews can be considered equally capable with regard to capability to fly various types of missions. Specifically, all crews in the theater can be assumed to be capable of performing required tactical maneuvers (terrain-following flight, short field and maximum effort landings, and airdrops). This has been MAC policy for many years and has proven to be a viable concept.

Crew Day Considerations. A primary limiting factor on crews is the crew day/crew rest cycle. In peacetime, crews are limited by MACR 55-130 to sixteen hours from initial preflight briefing to completion of the last official postflight activity (usually soon after the last home offload or engine shutdown); this limit is twelve hours if the mission any of the previously listed tactical maneuvers. Crew day is limiting in that a crew cannot undertake a new mission which would require that it exceed its crew day; on the other hand, missions once begun will normally be finished regardless of expiration of crew day. For model simplification, crew day length will be uniformly applied to all crews regardless of type of mission.

In practice, crews in Alaska usually return to Elmendorf to crew rest except in special circumstances; in any case, crew rest in wartime would not be planned for outlying bases except in emergency conditions or for a grounded aircraft. The model, therefore, can assume that all crews will begin and terminate their duty periods at home base, regardless of conditions which may keep them "in the system" in excess of their crew day. The minimum time between the end of one crew duty day and the beginning of the next is twelve hours, which provides for eight hours of sleep and time for pre- and postflight personal activities. Regardless of crew day length, the 12-hour crew rest period has been proven to be the minimum acceptable on a long-term basis (more than a few days). Therefore, the model assumes that the 12-hour crew rest period is mandatory between crew duty periods and cannot be interrupted once begun, and that all crew rest and crew changes must be conducted at home base.

Under normal conditions a crew's duty day includes considerable time before takeoff for preflight briefings and

inspections -- sometimes up to several hours. In major exercises, this time has been reduced significantly by use of nonflying crews to preflight aircraft, perform flight planning, and prepare and give briefings. It can be assumed that this would also be the case in wartime Alaska, and that crew day for flying crews will start at beginning of initial home-base cargo onload and end when the last home-base offload is completed. (The model must assume that all crews are flying crews; "overhead" crews are assumed to be available.) Additionally, the twelve-hour crew rest period is considered to begin immediately upon completion of crew day, and crews are available for reassignment immediately on completion of crew rest. For model simplification, crews are assumed to be indefinitely available for assignment on completion of crew rest; in reality an "alert window" of about six hours would be used, after which a crew would be returned to crew rest. Like some other features of the peacetime system, the alert window might be subject to very liberal interpretation in wartime.

Airfield Types and Limitations

As might be expected in a large and essentially roadless region, Alaska has a great number of airfields, of which over 200 have been identified as potentially usable by C-130 aircraft. However, in the initial wartime scenario only a few dozen of these would be of concern, and these could be further grouped into two representative classes: main base complexes and forward-area airfields.

Main Bases. Main base complexes are considered to be the only airfields of importance in the Railbelt region, and consist of aggregates of major airfields in the Anchorage and Fairbanks

areas which are treated as single entities for model simplification. Elmendorf AFB and Anchorage International Airport can be combined into the Elmendorf complex, while Eielson AFB, Wainwright AAF, and Fairbanks International Airport constitute the Fairbanks complex. For theater airlift purposes, each of these complexes is considered to have unlimited ramp space and cargo-handling capability. (Parking areas are, in fact, very extensive at these locations, and Army load teams are expected to significantly contribute to cargo-handling capability.) Maintenance and refueling for C-130s, however, is limited to Elmendorf; maintenance considerations will be discussed shortly. Each main-base complex can be considered to have no traffic limitations thanks to multiple runways, taxiways, and instrument approaches, thus allowing aircraft at these locations to taxi, take off, and land simultaneously.

Forward Bases. All forward-area bases are considered to have traffic and cargo handling limitations, which usually vary from location to location and which can be regarded as resources particular to each such base. Forward-area bases comprise three categories: all-weather airports, CCI sites, and bare-base forward airheads. All-weather bases include military joint-use fields such as Galena and King Salmon and larger State airports such as Bethel and McGrath. These airfields have paved runways, precision instrument approaches, regular runway maintenance and snow removal, communications facilities, and usually some MHE.

Bare-base airports include all other airfields -- including forward airheads -- which are essentially VFR-only and which generally require use of assault landing and takeoff procedures. Bare-base airfields are usually unpaved, lack regular maintenance, and often have no permanent facilities. In some cases, they may

be abandoned military, mining, or oil exploration airfields which were originally built for C-130 use but are now in various states of disrepair. GCI sites are physically similar to base base airfields but differ in that they have regular maintenance, limited instrument approach capability, some PME, and communications facilities. However, GCI sites have only a minimal mission load, even in wartime (unless a GCI site were to be chosen as an Army airhead) and so can be treated in much less detail than other forward area bases involved with major mission flows.

Forward Base Saturation. Of key importance is that all forward airports have a maximum number of aircraft on the ground (MOG) which is used as a saturation point. MOGs at all fields are based on available ramp space only, and aircraft arriving at a saturated field must hold until space is available. (MOG at forward fighter alert bases is considered to be based only on that portion of the airport regularly available for airlift use; likewise, ground support and traffic limitations assume dedicated resources for and minimum conflict between airlift and fighter aircraft.) In general, saturation at forward bases is avoided by scheduling missions at intervals which keep holding to a minimum; this is particularly important in wartime because of threat considerations and the ever-present need to keep wasted flying time to a minimum. For this purpose, a separate "flow rate" figure based on MOG and anticipated average ground time can be used; for the forward airfield at Granite Mountain (used in ARCTIC CIRCLE 80), this figure was found to be about three aircraft per hour. Because of communications limitations in most of Alaska (VHF and UHF are useless at very low altitudes and HF is usually only marginally reliable) aircraft are assumed to be completely "out of touch" while enroute in forward areas; accordingly,

missions once dispatched cannot be held or called back -- the model's only control over forward base saturation, then, is in the scheduling process.

Cargo-Handling Capability. Cargo handling capability could become a factor at forward bases even though almost all offloads at such locations could be accomplished without MHE if absolutely required. However, use of MHE has been found to expedite forward base operations and is desirable if at all possible. Although some attention has been given to use of a specially modified 25K-loader at forward airheads, all-terrain forklifts have been the standard item of MHE in the field because of generally adverse conditions at most forward airheads (mud, snow, uneven ground, and lack of maintenance). In any case, these two types of equipment can be considered to constitute all forward-area MHE in Alaska.

Fighter alert bases such as Galena already have small in-place aerial port detachments with MHE; GCI stations usually have a single forklift and operator (which is normally sufficient for their very limited needs). At bare-base airheads such as Granite Mountain, MHE and accompanying Air Force personnel would be airlifted in on the first few aircraft to land. For model purposes, all MHE and Air Force personnel are considered to be aboard the first aircraft to land at a bare-base forward airhead. Further, all MHE (at any location) is assumed to have sufficient operators and support to allow it to operate around the clock.

While MHE is desirable for offload, it is essential for onload of palletized equipment. At forward airheads, however, the heavy initial flow is outbound from the main base areas, with MHE onloads at these locations limited largely to empty pallets, empty fuel bladders, and the odd piece of damaged equipment being returned for repair. Accordingly, MHE at bare-base forward

airheads would probably be less critical during the the initial outward push than during a redeployment. Accordingly, the model assumes that offloads can be accomplished if need be without MHE, while onloads always require MHE.

Number of Bases. In most exercises concerned with wartime Alaska, airlift activity has been centered on a handful of bases: the main bases at Anchorage and Fairbanks, a forward Army airhead, and one of the forward fighter alert bases used as a staging base for the move to the Army forward airhead. Thus, for a preliminary model such as the one currently being discussed, the important aspects of wartime airlift in Alaska can be captured in a five-base network: the two main bases, a forward fighter alert base, a forward Army airhead, and a single GCI-type base (which can represent all such bases because of their low rate of use).

Aircraft Maintenance and Reliability

Even though aircraft reliability and maintenance must be considered in an Alaskan theater model, it is not the purpose of the author to conduct an in-depth analysis of maintenance data for C-130s in general or for Alaska in particular. Since this data is not well organized and in some cases is not available, such an analysis would in itself constitute a major project. Further, there can be no attempt to model the home-base maintenance activity system in more than minimal detail in order to maintain model simplicity. Therefore, aircraft reliability and maintenance accountability will be modeled only in a very broad-brush manner.

Maintenance and reliability affect the Alaskan airlift system in two ways: by causing aircraft to need extra time for troubleshooting and repair and by causing aircraft to abort underway missions. The former reduces aircraft availability for

scheduling at home base and also delays aircraft with missions already assigned (both at home base and at outlying locations). Aborts are more disruptive to the mission flow since they require an aircraft to interrupt execution of its assigned mission and return to home base; aborted missions must usually be assigned to another aircraft, almost always with extra delay involved for offloading, rescheduling, and onloading.

Home Base Maintenance. As previously discussed, all Alaskan C-130 maintenance capability is confined strictly to Elmendorf and considered to be essentially unlimited in terms of manpower, equipment, and parts. The desired purpose of the maintenance function in this model is only to reflect the delays which aircraft would incur for required maintenance on each transit of home base, and a detailed treatment of the maintenance network is unnecessary. (Study of maintenance networks has already been the topic of several intensive analysis efforts, and is beyond the scope of this model.)

Although the author had a "ball-park" idea of what these maintenance delay figures should be, attempts were made to find existing data for confirmation and refinement. The first source considered was Air Force Acquisition and Logistics Division (AFALD) Pamphlet 800-4, "Acquisition Management Aircraft Historical Reliability and Maintainability Data." This document is one of the most comprehensive of all maintenance summaries for Air Force aircraft, and provides data for all models of the C-130 back to 1972. Data from this document can provide an exact number of "maintenance events" for each major aircraft system for a given period, and can as well give an average number of manhours spent on each event (Ref 1).

However, this data was found to be of little help in this case, since the manhour figures could not be related to actual delay encountered by each aircraft (average number of men working on each problem was not available). Further, no time distribution could be found because the figures gave only total numbers of activities and manhours per system. And lastly, even the average figures were far too high to be reconciled with the author's experience. Although these figures may be representative of the cost in manhours to operate a C-130 fleet in peacetime over a long period of time, they do not reflect the actual figures which affect day-to-day flying operations. In particular, these figures are nearly an order of magnitude higher than the real-life delays which the author encountered during exercises which approximated the conditions under consideration for this model.

Another source of maintenance delay figures was found at HQ USAF/SACM (Studies and Analysis, Mobility Branch). Faced with much the same problem as the author, analysts in that office have constructed a simple model of the C-130 maintenance delay flow (called "TRI-ORBIT"). Their data indicates that from landing to takeoff at home base a C-130 could expect to have no appreciable delay 48% of the time, approximately 30 minutes of delay 11% of the time, about 10.5 to 12 hours 37% of the time, and much longer delays for the remainder of the time (Ref 22). These figures, while more specific and appropriate than the AFALD 800-4 figures, still yielded an average maintenance delay per home-base transit of over five hours. Again, these figures were much higher than those actually experienced by the author, although they could possibly be considered an upper bound representing unusually adverse conditions.

In the absence of any formal data which seemed reasonable, the author was forced to draw upon his experience to account for maintenance delay in Alaska. The end result is a home-base maintenance network which looks at four possible maintenance areas for each aircraft arriving at home base. First, each aircraft is given 10 to 30 minutes of minor maintenance, regardless of any other indicated problems; this would account for thruflight inspections and such items as changing light bulbs or making minor adjustments to radios. Next, each aircraft has a probability of problems in one (or more) of three major system categories -- engines (4%), propellers (4%), and "other systems" (7%). This breakdown was decided upon after discussions with HQ USAF/SAGM modelers which verified the author's initial estimate that about half of all significant problems in the C-130 concerned engines and/or propellers (Ref 18). In addition to these set probabilities, an aircraft automatically receives maintenance for any major system identified as having caused an abort (discussed shortly).

If engine or propeller maintenance is indicated, the aircraft runs a 10% risk of major maintenance (engine change, etc.) and 90% of minor repairs (adjustments, simple component replacement, etc.). Problems associated with engines and propellers are always repaired and the aircraft returned to FMC status, based on the assumption that these two systems are essential for flight. For "other" systems, the probability is 50% that the problem can be fixed and 50% that it cannot; if fixed, the aircraft is returned to service in FMC status, and in FMC status if not. Each time a FMC aircraft undergoes maintenance it thus has a 50-50 chance of being returned to FMC status. In any case, an aircraft is never "grounded" at home, although it may be considerably delayed by

maintenance activities and may be returned to service in a degraded status. (The possibility of nonreparable damage or nonavailability of parts is not addressed; for the present, all maintenance problems are considered to be ultimately resolvable.)

Service times for these activities were drawn from the author's experience; distributions are assumed to be triangular. (The triangular distribution is useful when minimum, maximum, and most likely values can be determined and a piecewise linear density function seems appropriate (Ref 17:30).) The approximate range of these times was confirmed by discussions with Alaskan airlift operations and maintenance personnel during the past year (Ref 9). Since proper operating procedures can usually keep cold weather reliability rates reasonably close to non-winter rates, winter and cold temperatures would primarily affect maintenance through extended service times for outdoor activities. Since data for this aspect of maintenance is totally unavailable, summer service times are approximately doubled for winter conditions.

Aborts. Aborts can occur either inflight or on the ground; the primary distinguishing feature of aborts is that they involve the interruption of the execution of a mission. A HQ USAF/SACM study has indicated that C-130 maintenance failure rates are heavily dependent on sortie rates rather than actual equipment operating time (Ref 18). For theater airlift model purposes, then, the effect of aborts needs to be reflected in an abort rate, or probability of abort per sortie. Fortunately, some usable data is available for C-130 maintenance-related aborts, primarily in a 1977 study by the Air Force Human Resources Laboratory (AFHRL) (Ref 3). This study indicated that aborts occurred with nearly equal frequency in the air and on the ground, and that about half of all aborts in both cases resulted from engine and/or propeller

problems. Further study by HQ USAF/SACM indicated that about half of the air aborts occurred on takeoff/climbout or descent/landing, and that overall abort rates could be approximated by a 5% probability of abort per sortie (Ref 18); these figures agreed closely with the author's operational experience. (It should be noted that the AFHRL study indicated an overall abort rate of 2.8%, which both the author and HQ USAF/SACM personnel regarded as low, even under wartime conditions. It is possible that this disparity is due to a slight difference in definition of abort events between operations and maintenance reporting systems.)

For the Alaskan model, the 5% figure is appropriate. Aircraft are considered to be exposed to risk of abort in three instances: enroute, engine start, and engine shutdown. For enroute aborts, every aircraft is assessed a 2.5% chance of abort on each sortie; the affected system is then identified and flagged for appropriate home base maintenance action using the "standard" breakdown of 25% engines, 25% propellers, and 50% other systems.

Engine start and shutdown abort probabilities are 1.25% each, with affected component being decided as outlined above. Since engine-running offloads and onloads are used wherever possible at forward bases, the start/shutdown probabilities apply only when an aircraft's ground time exceeds (or can be expected to exceed) 45 minutes, which is a reasonable cutoff for engine-running ground operations in Alaska. This feature means that the full 5% abort rate applies only to sorties with both engine start and shutdown; some missions, therefore, will be subject to 2.5% or 3.75% abort rates, reflecting the fewer problems involved in engine-running ground operations. All aircraft must shut down engines at home base and so are subject to engine start problems when beginning a mission; likewise, the probability check by the home-base

maintenance event can be considered to include home-base shutdown problems. To reflect non-critical problems which inevitably occur in field situations but which merely cause delays rather than cause aborts, small percentages are included in the start and shutdown checks for delay-only problems; these problems simply impose a short (up to an hour) delay on the aircraft before it can proceed.

The model also reflects in a limited way the possibility that an aircraft can be grounded at an outlying base. This is done by including a very small probability of a grounding problem in the start and shutdown checks. If an aircraft is grounded, its cargo is offloaded and made available for pickup and continuation by another aircraft and the aircraft itself is put on "hold" at its current location until a maintenance mission can arrive from home base. (These maintenance missions are commonly called "rescue" missions.) Once the rescue mission has arrived and has offloaded maintenance equipment (a new engine or tire or perhaps only critical parts, as well as personnel and equipment to perform the repairs) the grounded aircraft is allowed to begin repairs, which customarily take considerable time; no figures of any kind are available for this activity, so the figures used are strictly based on the author's experience. (Groundings are not allowed at base-base forward airheads or at GCI sites under the assumption that such airfields would be subject to enemy threat; in wartime emergency cases, C-130s can almost always take off even with major system failures, to include inoperative engines or propellers.)

Abort Routing. All aborting missions are constrained to return to home base, under the twin assumptions that all maintenance is at home base and that it is easier to reschedule a mission from home base than from an outlying base. (This is a

major difference from the European scenario, where an aborted or diverted load could use surface transportation to move from one forward base to another.) On arrival at home base, it is assumed that the aborting aircraft will not be available for mission continuation (due to maintenance, etc.), thus requiring that the aborted mission be offloaded and made available for rescheduling. If a mission is aborted while only partially completed, the remaining cargo and itinerary constitute a "continuation" mission with the original mission number, ready time, risk, and priority; this ensures that swift attention will be given to completion of aborted missions. This continuation mission is then made available for rescheduling, and the original mission is not considered complete until the continuation mission is finished. If an aircraft aborts on a position leg (enroute to pick up its mission) its intended mission is immediately made available for rescheduling. In some cases, such as a grounded aircraft, a continuation mission may be entered in the system at an enroute base.

Geography, Threat, and Weather

Alaska can be divided into two regions: the central/southcentral Railbelt containing the major population centers and main bases, and the forward operating area encompassing the Aleutians and western and northern Alaska. The primary difference between the two areas is existence (or absence) of road and rail transportation networks.

The forward operating area can be divided into several zones for ease in assessing weather and threat considerations (Figure 5). Generally, these areas represent major geographical divisions of the state which tend to have internally consistent weather

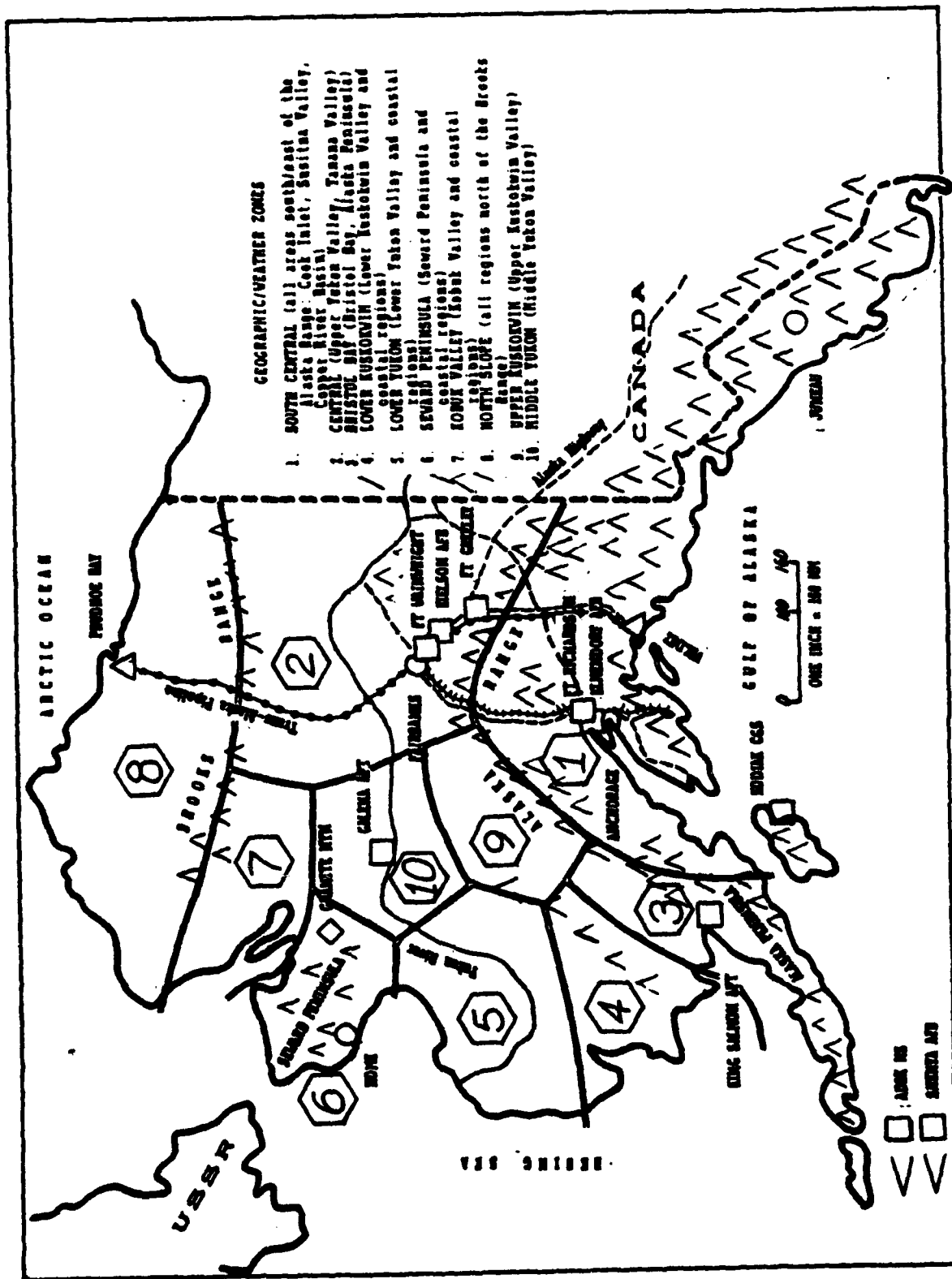


Figure 5: Geographic/Weather Zones

patterns (e.g., the entire Lower Yukon Valley would go below weather minimums at once). Weather patterns and enemy activity are assumed to have interrelated effects on airlift mission capability in the forward area.

Enemy Activity. While operations in the Railbelt area can be considered far enough "behind the lines" to be free from enemy attack, forward-area airlift missions could have to contend with hostile action. An enemy incursion of less than division size in western Alaska would necessarily be forced to spread out over a large area if movement into the interior of Alaska were desired. In so doing, the density of enemy forces would be very low, completely unlike conditions expected to obtain in central Europe. In all probability, there would be no continuous FEBA, but rather a series of force concentrations with little or no enemy presence between major areas of activity (Ref 15).

Since airlift aircraft have no self-defense capability other than low-level flight and use of terrain masking and camouflage, airlift missions would strictly avoid known or suspected enemy forces. Airlift missions near known enemy concentrations (such as traditional mass airdrops on enemy rear areas) would not be attempted, although carefully planned and executed special-operations-type missions within the enemy area of control should be possible because of the very low force density anticipated (Ref 15). Accordingly, threat can be considered to be air-to-air only.

Most airlift missions would traverse areas with little or no enemy activity, and accordingly could be safely conducted. However, enemy fighters could operate from captured western-Alaska airfields and thus present an air-to-air threat to airlift. Exercises in Alaska have shown that C-130s at low altitudes (500

feet or less above the ground) can usually avoid detection by enemy aircraft, even without escort. With escort (or even with friendly fighters operating in the same vicinity), airlift aircraft using low-level tactics run virtually no risk of intercept. However, C-130s which cannot use low-level avoidance and concealment are very vulnerable, even with escort. It should also be noted that an intercept of a C-130 by a fighter would undoubtedly result in a kill, so probability of intercept for this discussion can be equated with probability of kill (Ref 15).

Since weather is virtually the only factor which prevents use of low-level tactics, weather conditions must be considered when evaluating threat and risk. The least desirable condition would be weather such as fog or low clouds which prevents low-level flight. This would force airlift aircraft to climb to higher altitudes where risk of detection by enemy fighters would be much greater; without escort, this would be a high-risk situation, and even with escort, it could still be considered as presenting a moderate risk. Clear weather, on the other hand, would allow use of low-level tactics, but would present at least a small chance of visual detection by enemy fighters; this would be a low-risk situation, and presence of escort would remove virtually all risk. Middle level clouds would be the ideal condition for airlift, since low-level flight would be possible and enemy fighters would probably be forced to remain above the clouds; airlift aircraft would probably require no escort at all in this situation.

Weather and Darkness. Weather can be assumed to fall into one of four categories -- clear (or high clouds), middle clouds, low clouds, and fog. Clear weather permits all types of operations, as do middle cloud conditions. Low clouds are such that low-level flight (visual terrain-following flight at less

than 1000 feet above the ground) is not possible, although nonprecision approaches can be successfully completed. (Airdrops are considered to be possible if nonprecision approach minimums can be met.) Fog prohibits all low-level and approach operations except for approaches to facilities having precision instrument approach facilities (ILS or GCA).

No distinction is made between night and day for low-level and airdrop missions, since the cover offered by darkness is usually thought to offset the substantially higher enroute altitudes required. Moreover, use of Station-Keeping Equipment (SKE) allows much flexibility in night formation missions, and greatly reduces problems previously caused by inadvertent weather penetration (Ref 15). Operations at forward airfields can usually be conducted at night, provided that even minimal field lighting can be provided; forward airfields involved in large-scale moves can be assumed to be lighted.

Enroute Time. Since distance is one of the major considerations in Alaska, flying times between bases for airlift aircraft must be carefully examined. Generally, airlift enroute times fall into two categories: normal and low-level. Low-level segments are flown at lower airspeeds (generally about 230 knots, vs 280 knots for normal cruise) and are also generally about 25% longer than direct routings because of terrain considerations. Accordingly, missions through threat zones would require about 50% more flying time than non-low-level missions through threat-free areas, resulting in a decreased mission capability for a given amount of flying time.

For model simplification, only a single flying time will be used between any pair of locations; this time will assume low-level flight in forward zones and normal flight in rear zones,

and direct routing between all locations. Additionally, each point-to-point routing will be assumed to transit a specific sequence of weather/threat zones. Since airlift crews on low-level missions routinely practice making times of arrival (TOAs) within plus or minus two minutes, these times can be assumed to be unvarying.

Summary of Assumptions

This chapter has outlined the major assumptions necessary to incorporate various system components into the model. The most important of the assumptions are:

Theater Airlift Requirements:

- All requirements are identifiable and consist of missions which can be treated as individual entities.
- Inputs from outside the theater will be negligible.
- Each mission has a priority, an acceptable risk level, and an earliest time available.
- Missions are presized for C-130 movement and have preset itineraries.
- Each mission has a specific load type, either requiring MHE or not requiring MHE.
- Onload/offload times assume wartime operations; times are doubled for winter.
- Airdrops are single-ship, either cargo or personnel, and must terminate at Elmendorf.
- Airdrops can only be executed at forward airheads or GCI sites.
- Missions are either tactical or non-tactical;

aircraft are similarly tactically (fully)
capable or non-tactically (partially) capable.

Aircraft and Aircrews

- The system uses only C-130s; the CRAF is not considered.
- All aircraft and crews are based at Elmendorf, as are all maintenance and fueling facilities.
- All aircraft and crews are available and in fully capable condition at the start of the simulation.
- Lost resources will not be replaced.
- C-130 model differences do not cause significant operational problems.
- Crew day begins at crew arrival at the aircraft prior to the first onload and ends after the last offload; crew day length is the same for all crews regardless of mission type.
- Crew rest is 12 hours and must be conducted at Elmendorf; crews are indefinitely available for assignment once rested.

Airfield Types

- Theater airlift activities can be adequately represented by a five-base network.
- Airfields can be categorized as main-base or forward base.
- Conflict with other theater flying activities will be negligible at all bases.
- Main bases are aggregates of major airfields and have no traffic or cargo-handling limitations.
- Forward bases have limited ground space and cargo-handling capabilities and are subject to flow

restrictions to prevent excess delay.

- Forward-base MHE consists only of forklifts and K-loaders.
- All forward-base MHE is assumed to be in-place.
- Palletized cargo can be offloaded without MHE if required; palletized onloads must have MHE.

Maintenance and Reliability

- Maintenance and reliability affect aircraft flow by causing delays and/or aborts.
- Maintenance checks are mandatory each time an aircraft transits home base.
- Home-base maintenance can be represented by a simplified activity causing delays of varying length for aircraft.
- Aborts can be represented by a (maximum) overall 5% chance of abort per sortie.
- Aircraft cannot suffer grounding problems at forward airheads or GCI sites.
- All aborts must return to home base; aborting aircraft cannot continue an assigned mission.

Geography, Threat, and Weather

- The theater can be divided into ten zones for weather and threat consideration; weather is the same for all locations within a zone.
- Ground threats in forward areas can be avoided; airlift aircraft must contend only with air-to-air threat.
- Risk can be categorized as low, medium, and high and is uniform throughout a zone; probability of detection/kill can be represented by a

set probability for each category.

-- When present, escort protects all missions in a zone.

-- Weather conditions can be represented by four levels: good, medium, bad, and fog; each level has various effects with regard to threat and instrument approach capability.

-- Flying times between bases are fixed.

The next chapter will discuss the computerization of the model and the particular methods by which the assumptions were incorporated into the SLAM/FORTRAN program.

IV. Computerization

Overview

Having examined the various factors which must be included and having made certain assumptions about their treatment, the computerization of the model itself can be described. This chapter will first discuss the selection of the simulation language and the concept underlying the construction of the model. The model itself will then be described, with particular attention given to the mission entry provisions and the scheduling function. Finally, special features of the model will be outlined.

Language and Concept of Construction

Since the system consists of entities (missions) which must be moved from point to point via specified routings, and since many of the factors affecting this flow have limits on their utilization, a simulation language which incorporates both networks and queues would be appropriate. Two such languages are currently available -- Q-GERT (Graphical Evaluation and Review Technique with Queueing) and SLAM (Simulation Language for Alternative Modeling) (Refs 16,17). Both are FORTRAN-based and allow for various modes of network switching as well as for automatic generation of random variates. SLAM, however, incorporates all of the features of Q-GERT and makes many improvements, and additionally allows intermixing of discrete and network modes of simulation. Most importantly, SLAM allows virtually unlimited use of FORTRAN inserts to amplify network activities, thus giving the modeler a very high degree of control over model operation (Ref 17).

This model was begun in Q-GERT, but it was rapidly apparent that SLAM could provide much more flexibility. In particular, SLAM allows the consolidation of the very complex scheduling function into a single FORTRAN subroutine, thus saving more than a hundred nodes and activities. Given the ability to effect such consolidation, it would be possible to completely eliminate the network; however, the author has found it more useful to strike a compromise, keeping the network framework intact for ease of visualization while combining complex or repetitive activities into well-documented FORTRAN subroutines. This has the additional benefit of allowing much of the model to be pre-compiled and stored as a binary object file, resulting in much less memory and time required for loading and compilation.

SLAM provides another major advantage in its use of "global variables", which can be individually set for each run and which can be used to control almost all network functions such as branching. When combined with SLAM's ability to allow multiple runs with changing of global variables and other conditions between each, the possibility exists to design a model whose parameters can be controlled almost completely by use of global variables (Ref 17). This, in turn, permits the model to be used to execute complicated experimental designs with a minimum of effort. The author designed this model for such control; Tables I and II list the global variables which can be used to set levels for various factors (and their-default values).

Network Description

Network Circulation. In general, the model circulates aircraft entities through a system of five bases, representing the four types of base determined to be of most concern in the Alaskan

TABLE 1: GLOBAL VARIABLE LISTING (PART 1)

IA = USER SETS INITIAL VALUE, MODEL MAY ADJUST DURING EXECUTION

I = USER SETS INITIAL VALUE; FIXED PARAMETER

C = CLOCK OUTPUT OR CLOCK-CONTROLLED

* = INTERNAL USE ONLY

X = NOT CURRENTLY USED

NO.	CONTROLS	TYPE	DEFAULT
1	- NO. OF AIRCRAFT	(IA)	10
2	- NO. OF CREWS	(IA)	15
3	- NO. OF SPARE ENGINES	(IA)	50
4	- NO. OF SPARE PROPS	(IA)	50
5-9	- X		
10	- CREWDAY IN MINUTES	(I)	960
11	- LOW-THRT PROB KILL	(I)	3%
12	- MED-THRT PROB KILL	(I)	5%
13	- HI-THRT PROB KILL	(I)	10%
14-19	- X		
20	- ETALST INITIALIZATION	(*)	
21	- RUN TERM ENABLE SWITCH	(*)	
22	- MSN ENTRY COUNTER	(*)	
23	- MSN COMPLETION COUNTER	(*)	
24	- CLOSURE TIME FOR RUN TERM	(*)	
25	- X		
26	- TIME-OF-DAY	(I)(C)	00
27	- DAY/NIGHT OUTPUT	(C)	
28	- DAY LENGTH	(*)	
29	- START HOUR	(*)	
30	- DAY NO. (BASED ON XX(26))	(C)	
31	- SEASON (1=SUM, 2=FALL, 3=WINT, 4=SPR)	(I)	1
32	- DAY/NIGHT ENABLE (0=N, 1=Y)	(I)	1
33	- X		
34	- WX OPTION (0=PRESET VALUES, 1=ALL CLEAR, 2=VARY)	(I)	0
35	- MHE OPTION (0=FIXED, 1=VARY)	(I)	0
36	- ESCORT OPTION (0=NONE, 1=ALWAYS AVAIL, 2=VARY)	(I)	1
37	- THREAT OPTION (0=NONE, 1=PRESET, 2=VARY)	(I)	0
38-40	- X		
41-50	- ZONE WEATHER	(I)(C)	2
51-60	- ZONE THREAT	(I)(C)	0

TABLE II: GLOBAL VARIABLE LISTING (PART 2)

NO.	CONTROLS		TYPE	DEFAULT
61 -	MOC BASE	1	X	
62 -		2	X	
63 -	[RESOURCE	3	(IA)	6
64 -	"MOC"]	4	(IA)	2
65 -		5	X	
66 -	MAX NO ON APP/DEP BASE	1	X	
67 -		2	X	
68 -	[RESOURCE	3	(I)	2
69 -	"ATC"]	4	(I)	1
70 -		5	X	
71 -	FORKLIFTS BASE	1	X	
72 -		2	X	
73 -	[RESOURCE	3	(IA)	4
74 -	"FK"]	4	(IA)	2
75 -		5	X	
76 -	K-LOADERS BASE	1	X	
77 -		2	X	
78 -	[RESOURCE	3	(I)	1
79 -	"K"]	4	(I)	0
80 -		5	X	
81 -	INSTR APPRCH CAPY BASE	1	(I)	2
82 -	0-NONE	2	(I)	2
83 -	1-NONPRECISION	3	(I)	2
84 -	2-PRECISION	4	(I)	1
85 -		5	(I)	1
86 -	HOURLY FLOW RATE BASE	1	X	
87 -	(MAX NO OF	2	X	
88 -	SCHED ARRVLS	3	(I)	6
89 -	PER HOUR)	4	(I)	3
90 -		5	(I)	2
91-96 -	X			
97 -	SCHED TRACE (LEVELS 2 - 9)	(I)		0
98 -	MTRACE AND MISC (LVL 1 - 3)	(I)		0
99 -	MISC PRINT (LEVELS 1 - 3)	(I)		0
100 -	X			

theater. At the various locations, mission entities are loaded on the aircraft, which are then routed through the network dependent on their assigned mission. By using aircraft entities as the primary "movers" in the system, mission entities can be removed once they are "loaded". This keeps the total number of entities in the system to a minimum, thus reducing the size of the model. (Table III outlines attribute allocation for both mission and aircraft entities.) As aircraft complete their missions, they are freed for reassignment, subject to certain limitations which will be detailed later.

Network Phases. The network consists of the four mission phases outlined earlier: the continuation/scheduler phase, the departure phase, the enroute/approach phase, and the arrival phase. Aircraft arriving at a base must pass through the arrival phase, the continuation/scheduler phase, and the departure phase in sequence. Each base has a separate arrival and departure subnetwork, modeled to represent specific conditions obtaining at that base. Figure 6 outlines the overall network flow; Figures 11 through 18 in Appendix A show the networks and subnetworks for each phase and base.

The arrival phase consists of approach, landing, taxi-in, and cargo offload (if any). Different bases have different structures for each. Following completion of the arrival phase for a base, an aircraft is routed to the continuation/scheduler phase, which notes the aircraft's location. The first part of this phase is a continuation check, which checks for mission completion; if the mission is not complete, the mission information is restructured for the next leg and the aircraft is routed to the its current-base departure subnetwork. If the mission is complete, the continuation subroutine sends the aircraft to the scheduler,

TABLE III: ATTRIBUTE LISTING

AIRCRAFT ENTITY		MISSION ENTITY	
1 -	LAST TIME BEGAN HOME MX	MSN READY TIME	
2 -	ACFT MX STATUS (1,2, OR 3)	ACFT STATUS REQUIRED	
3 -	FLY TIME SINCE HOME	UNIQUE MSN NUMBER	
4 -	ENGINE START/STOP MARK	RISK LEVEL ALLOWED	
5 -	CUMULATIVE FLY TIME	MSN PRIORITY	
6 -			
7 -	(8-9 NOT USED)		
8 -			
9 -			
10 -	CREW DAY START MARK		
11 -	ABORT STATUS FLAG (0-4)		
12 -	CURRENT LEG ORIG BASE	(8-19 NOT USED)	
13 -	ONLOAD		
14 -	OFFLOAD		
15 -	DEST BASE		
16 -	NETWORK ROUTING SWITCH		
17 -	ACTIVITY TIME		
18 -	MX FAILURE CODE (3,4, OR 5)		
19 -	RESCUE SWITCH		
20 -	NEXT LEG ORIG BASE	20-32 SAME FOR MSN ENTITY	
21 -	ONLOAD		
22 -	OFFLOAD		
23 -	DEST BASE		
24 -	ONLOAD		
25 -	OFFLOAD		
26 -	DEST BASE		
27 -	ONLOAD		
28 -	OFFLOAD		
29 -	DEST BASE		
30 -	ONLOAD		
31 -	OFFLOAD		
32 -	DEST BASE		
33 -	RESTNT ROUTE SWITCH	ETE FROM ORIG TO FIRST DEST	
34 -	GNDTIM/LEGTIM	SECOND DEST	
35 -	ONBOARD MSN RDY TIME	THIRD DEST	
36 -	TYPE ACFT REQ	FOURTH DEST	
37 -	MSN NO	(37 NOT USED)	
38 -	RISK LEVEL	EST MSN LENGTH BACK TO HOME	
39 -	PRIORITY	(38-40 NOT USED)	
40 -	RISK LEVEL FOR ACFT		

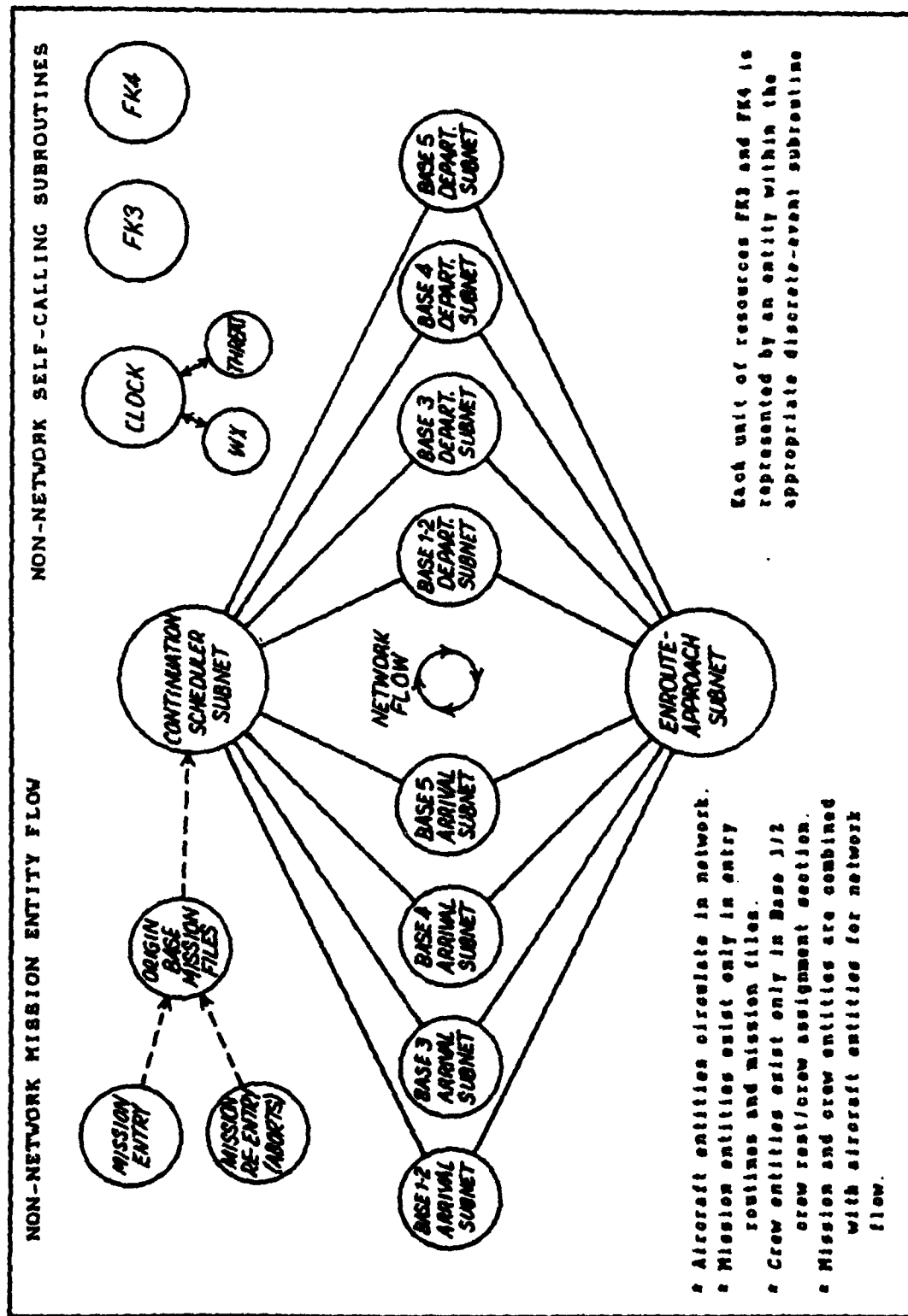


Figure 6: Overall Model Organisation

which checks for possible missions for the aircraft according to a specific set of rules. If a mission is found, it is assigned to the aircraft; if a mission is not found, the aircraft is scheduled for a "deadhead" leg to home base. In either case, the aircraft is then sent to the current-base departure subnetwork. The departure phase consists of cargo upload (if required), engine start, taxi-out, takeoff, and departure. On departing a base, an aircraft enters the enroute phase, which consists of an enroute subroutine and an approach subroutine. The enroute section checks weather and risk and reconfigures the aircraft for an abort to home base if required; it then assigns a flying time to the destination base and routes the aircraft to the approach section, which in turn passes the aircraft to the appropriate arrival subnetwork.

Home-Base Maintenance and Crew Change. The Base 1 arrival and departure subnets differ from those of the other four bases. Base 1 is considered to be the home base, and all maintenance, refueling, and crew rest facilities are located there. Accordingly, after an aircraft arrives at home base and is offloaded, it is automatically routed through a maintenance subroutine (MXMAIN) which checks for maintenance problems as previously outlined. The home-base departure net includes a crew-change section. Crews are assumed to be able to crew-rest only at home base, and aircraft can only receive new crews at home base. If an aircraft has a crew on board, and if the crew has sufficient time left to complete the mission, it stays with the aircraft; if not, the crew must be returned to crew rest and a new crew picked up. If no crews are available, the aircraft is not scheduled. (Crews may be returned to crew rest directly from the scheduler under some conditions at home base, thus leaving

aircraft in an uncrewed condition.) No loading can be accomplished until a crew is available (this is an assumption primarily for model simplification, although it is usually the case in practice -- loading and offloading must normally be supervised by the loadmaster). Crew entities reside only in the crew-rest section of the network; on assignment to an aircraft, the crew entity is "destroyed" and is represented on the aircraft entity by a crew mark time showing the start of the crew duty day.

Mission Entry

Missions are entered into one of the five base mission files either by the STACK subroutine, which reads an external data input file of up to 500 separate missions, or by the REP subroutine, which can be structured at the user's discretion and is most useful for repetitive or stochastic mission flows. (See listings of subroutines MSTACK and REP in Appendix B for details on setup and restructuring of mission input routines.) Each mission has a ready time (the earliest time at which it can be scheduled), an aircraft type required, a mission number, a risk level, and a priority; each mission also has an itinerary consisting of an originating base and up to four subsequent destinations, with onloads and offloads for each. Enroute to the mission files, the newly entered missions (or re-entered, for aborts) are processed by subroutine MENTIM, which computes estimated time from departure to each destination, as well as an estimated time required to return home if the mission does not terminate at home. Once in the mission files, the missions are ordered by priority (lowest value first). When scheduled, the data in a mission entity is "piggybacked" onto the aircraft entity and the mission entity is then destroyed.

Scheduling

The scheduler (Figure 7) is the "brains" of the system. It is triggered by the arrival of an aircraft from the continuation check at any base. The scheduler then examines the mission file for the current aircraft location; if no missions are found which are suitable, the scheduler looks at other mission files in a preset sequence (different for each base, but basically in order of proximity to the current location). If there are no suitable missions at the current location, the scheduler creates a "position" leg in order to position the aircraft at the prospective origination base. If the position base is above weather minimums for an approach, the scheduler notes the risk level required to fly to that base; no missions at that base will be scheduled unless they allow at least the risk level required to get to the base. The time required to get to the position base is added to the total estimated mission time for fuel and crewday limitation checks.

Within each base mission file, the scheduler looks for missions on a basis of priority, and within priorities on a basis of earliest ready time first. The scheduler checks for aircraft compatibility with mission requirements (FMC vs FMC aircraft), MHE availability, risk level, arrival time slot availability, crewday remaining, and fuel remaining. If a valid mission is found, subroutine SCHSET is called to complete the actual "loading". If no mission can be found at any base, and if the aircraft is not already at home base, the aircraft is routed home via a "deadhead" leg with no load. If already at home, the aircraft is put into a one-hour scheduling hold loop and is run through the scheduling process once each hour until a mission is found. (The listings in Appendix B of subroutines SCHED, WCHK, ETACHK, and DEDMED provide more information on the scheduling process.)

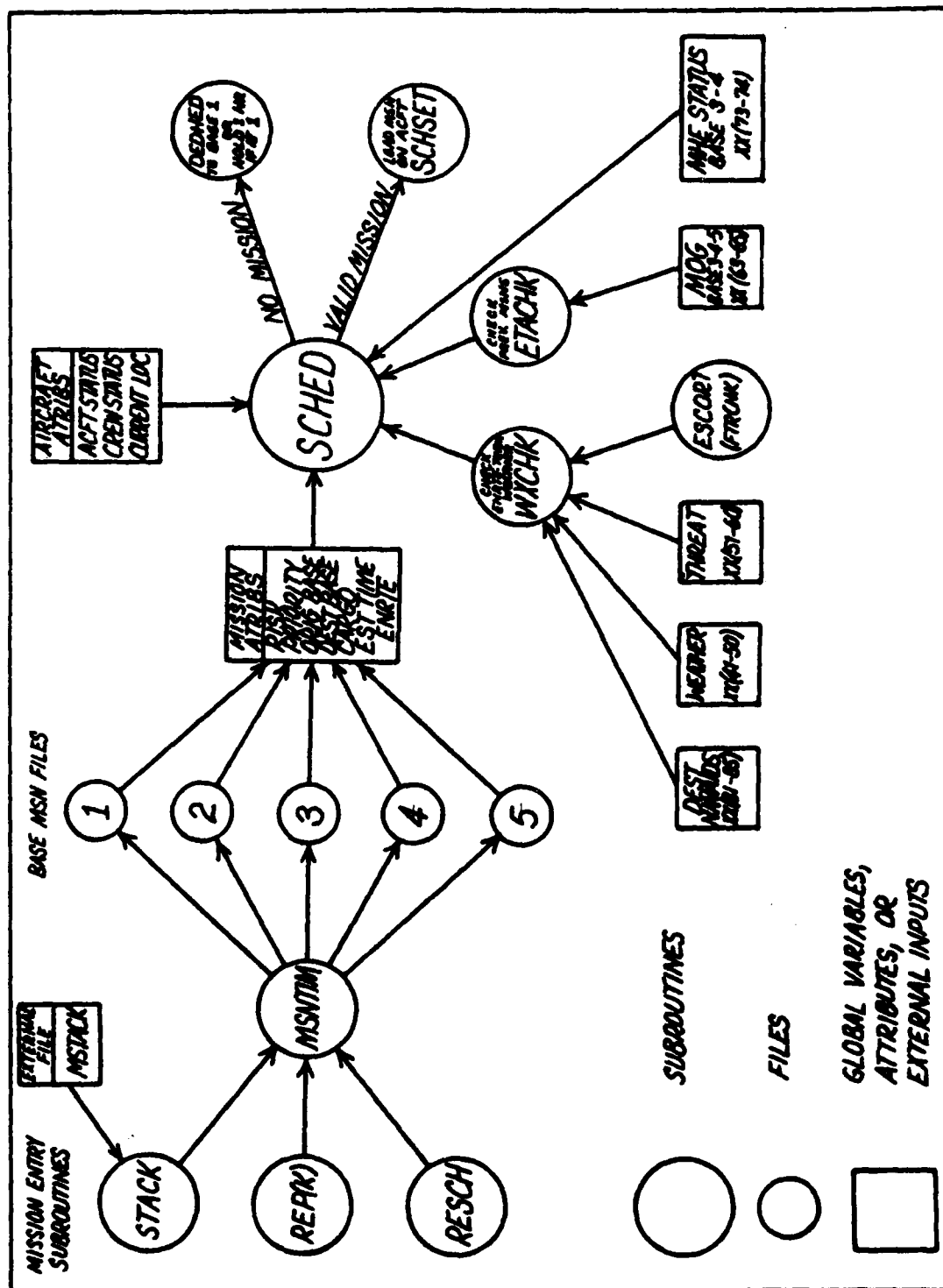


Figure 7: Scheduler Inputs

Crews are a special consideration for the scheduler at home base. Basically, if a fresh crew is needed to begin a new mission but no rested crews are available, the scheduling process will be terminated and the aircraft returned to the one-hour hold loop. For aircraft arriving at the scheduler with no crews (crew mark time in ATTRIB(10) set to zero), if no crews are available the scheduling process is bypassed and the aircraft sent directly to the hold loop. If an aircraft with a crew on board arrives at the scheduler, the entire scheduling process is executed. If a mission is found and the on-board crew has sufficient time to complete it, the aircraft is sent directly to the departure subnetwork. If not, and a crew is available, the aircraft is detoured to the crew change section, where the old crew will enter crew rest and a new crew will be picked up. If a crew is needed but none is available, the onboard crew will be sent directly to crew rest, the mission returned to the mission file, and the aircraft sent to the hold loop without a crew. The model does not allow crews to switch aircraft. Although this is occasionally done in practice, it is not considered a factor since there are usually no aircraft readily available and since such a switch is only profitable if done fairly early in the crew day. (In any case, allowing crews to switch airplanes would greatly complicate the scheduling and crew assignment process.)

In general, the scheduler will schedule a mission for an aircraft unless the mission is specifically rejected during one of the screening checks. The scheduling process assumes that all crews are equally capable and that all fully capable aircraft can accomplish any tactical mission (low-level flight, max-effort landings, airdrops, etc.), as well as any non-tactical mission.

The priority and earliest-ready-time system of assignments is the same as is used in practice, and the risk-level feature is an attempt to model a process which is informal but which occurs in every scheduling situation. The scheduler also assumes that any mission delay (due to delayed time slots at forward bases, etc.) will be taken before the mission departs, since delays at limited-capacity enroute bases are usually discouraged, especially in high-flow situations. Missions are checked "in toto" -- if any portion of a mission is not schedulable, the entire mission is rejected. The scheduler does not attempt to optimize missions; rather, it sequentially examines each mission in order of priority and ready time and then performs a feasibility check on each mission, scheduling the first mission which meets all criteria. It is assumed that the user will enter a predetermined sequence of missions, which the scheduler will then assign for execution in accordance with its internal rules; once entered, missions cannot be adjusted or modified -- this assumption is absolutely necessary to prevent the model from assuming level of complexity far above that required for its intended purpose. (The user would be well advised to keep missions as simple as possible, such as one load from one base to another, rather than build complex multi-leg missions which might never meet scheduling requirements for all legs.)

Special Features

The model includes several special features designed to enhance its realism and ease of manipulation. Three of these (WX, THRT, and ESCORT) were included primarily to demonstrate their feasibility and to provide a point of departure for further model development; these subroutines currently use default parameters

for some of their functions and can be significantly expanded if desired. However, the model as it exists is essentially complete and is capable of performing its intended function as a tool for analysis of the wartime Alaskan airlift system.

Initialization. INTLC subroutine is used to initially enter aircraft and aircrews, to set resource levels, and to make triggering calls to various subroutines responsible for keeping "real" time, setting weather and threat, and varying certain resources. Since subroutine INTLC is called after all INTLC statements (which set global variable levels) have been read for a particular run, the subroutine can reflect changes called for by the newly set global variables when it initializes the model. The initialization sequence is shown in Figure 8.

The Master Clock. Subroutine CLOCK tracks simulation time in 60-minute increments. It updates "real" time in the system based on a 24-hour day and returns the current hour in XX(28) and the current day number in XX(30). The user can enter a "real" simulation starting hour if desired. If the appropriate options are enabled, the clock calls for a weather update every six hours and for a threat update every midnight (see Weather and Threat, below). Additionally, CLOCK determines day and night based on season (with decreasing hours of daylight for summer, fall/spring, and winter). Although no model features currently use the day-night output, a switch is provided (XX(32)) to enable or disable it. The CLOCK feature is primarily used to insure that factors which depend upon time of day or upon number of days since the beginning of the simulation can be accurately reflected in the model.

Threat. The model offers three options for controlling the threat input: none in the theater (or preset and unchanging),

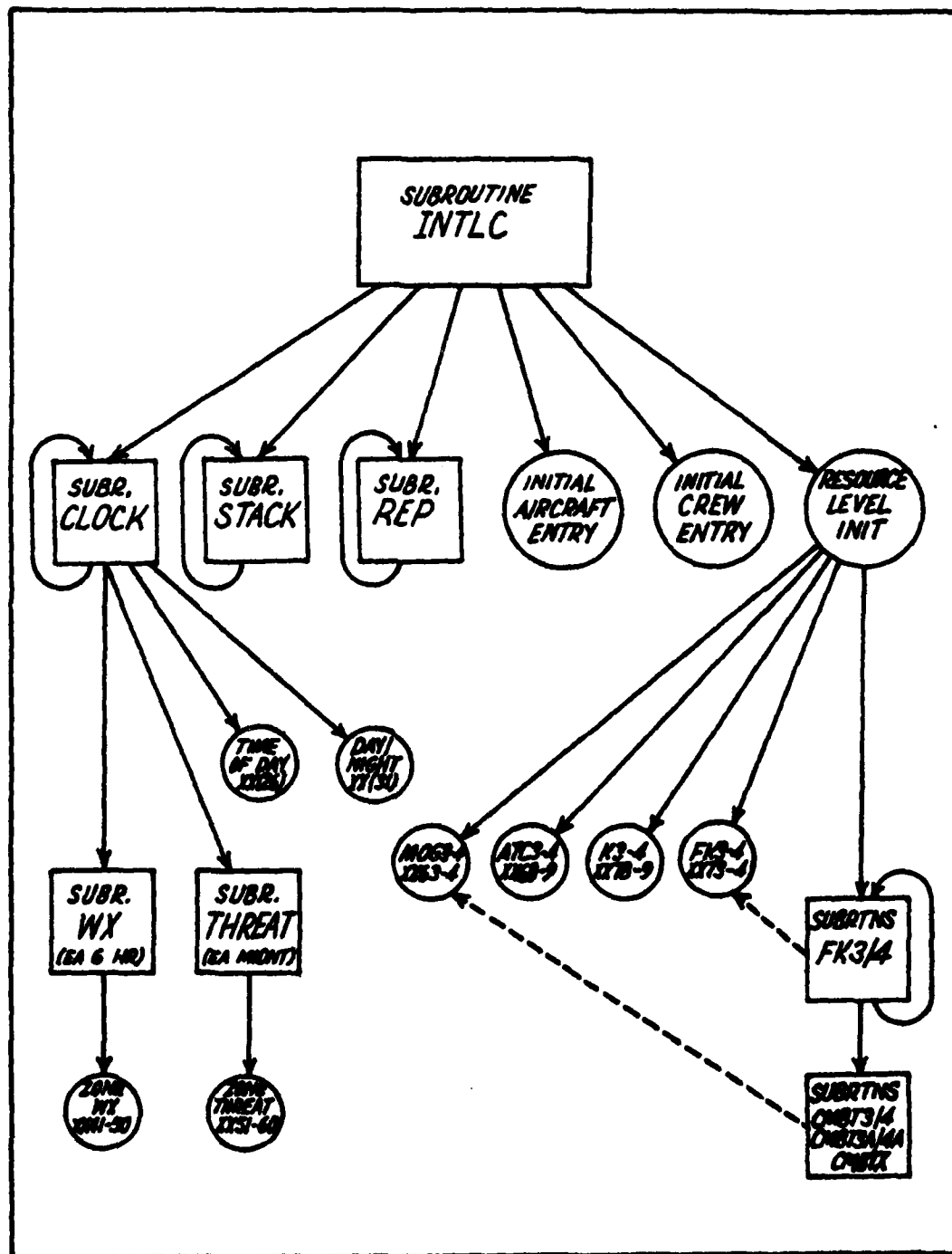


Figure 8: Initialization Sequence

threat in every zone, and varying on a day-to-day basis (as determined by subroutine THRT); these options are controlled by XX(37). The model does not attempt to detail individual enemy encounters, but instead assumes set probabilities of intercept (and thus kill) for each passage through an affected zone for appropriate risk combinations. The user can, however, set the probabilities of kill for low, medium, and high risk conditions (XX(11-13)).

Escort. Escort can be user-specified in much the same way as threat. However, escort is assumed to be available on an hour-by-hour basis which repeats every 24 hours. Thus, subroutine FTRCHK is called whenever escort availability needs to be checked. Using the "real" hour, FTRCHK consults a user-constructed data matrix which reflects escort availability in every zone based on time of day. The presence of friendly fighters in any zone is considered to constitute escort, and the model does not attempt to further break out numbers, on-station times, or actual locations. (In Alaska, the mere presence of friendly fighters within a radius of up to 50 or more miles was found to divert the attention of enemy fighters sufficiently to allow airlift aircraft low-level tactics to be effective (Ref 15).)

MHE Clocks and Combat Offload. Since MHE may not always be in commission, the model incorporates two discrete-event subroutines (FK3 and FK4) which vary the level of forklift resources at Base 3 (the forward fighter alert and staging base) and Base 4 (the bare-base forward airhead). Each forklift is assumed to be operational for an average of 18 hours and then down for repairs for a period averaging four hours. If all forklifts at a given base become inoperative, combat offload is authorized at that base. (See listings of subroutines FK3/4, CMET3/4, and

CMET3A/4A, and CMETX for details on the combat offload chain of events.) These "MHE clocks" must be specifically enabled by setting global variable XX(35) to 1.

Weather. The model allows the user three different modes for setting weather in the ten geographic zones -- individually preset and unvarying, defaulted to "all clear", and varying every six hours. These options are determined by setting XX(34) to the appropriate value; individual zone weather conditions may be set in XX(41) through XX(50). If the "vary" option is selected, subroutine CLOCK will call subroutine WX at 0300, 0900, 1500, and 2100 every day. Weather in each zone is varied by a Markov chain using empirical probabilities reflecting seasonal differences. Season, time of day, and existing weather are considered in a special fog-generating section. See the listing for WX for more comments. (Currently, the same Markov chain is used for all zones; it represents average data for the Cook Inlet area and was used primarily to check the performance of this particular feature of the model. If analysis using the varying-weather feature is desired, the user would need to restructure the WX subroutine to incorporate the remaining nine Markov chains, which can be constructed with data obtainable from the USAF Weather Service.)

FORTTRAN Print Routines. Subroutine MTRACE and various FORTRAN print routines and statements can provide a complete trace of model operation if "switched on"; this trace is independent of SLAM output and trace routines. XX(87) controls the trace routine built into the scheduler and can be set at various levels (2 through 9) to provide progressively more detailed tracing of scheduling functions. XX(88) controls MTRACE and other embedded print statements which serve to trace aircraft and mission entities through the network. XX(88) set to 1 will provide a

complete record of aircraft movements, and set at 50 will additionally provide a compact attribute dump at several key locations. XX(99) controls miscellaneous print statements not directly related to the other trace categories; it may be set at levels 1 through 3 for progressively more detailed tracing. All trace categories may be turned off by setting print switches to zero. These print routines were primarily built for debugging and verification purposes, but are also useful in providing a general picture of system flow trends under varying conditions.

Output Measures. In order to provide a basis for troubleshooting and verification and validation, as well as to provide overall measures of system performance, the model collects a number of statistics. Among these are average crew day length, flying time and fuel used while away from home base, ground times at all bases, aircraft utilization rate (flying hours per day), total number of sorties flown, number of missions entered and completed, and number of aircraft lost. Additionally, the model reflects queue and resource utilization statistics. Since a primary measure of airlift mission performance in Alaska is completion time for a particular stream of missions, the model counts missions entered and missions completed and reports the "closure time" of the stream when the last mission is completed. For figuring closure time, the model currently tracks entry and completion of all missions with mission numbers between 10000 and 59999; mission numbers of 60000 or greater are used for "incidental" missions such as aborts and deadhead sorties. The model will begin a shutdown process when the last mission is completed; final aircraft utilization and crewday statistics are collected as aircraft arrive at home base for the last time. For details of the mission completion and shutdown mechanism, see the listing in Appendix B for subroutine MTRACE.

Summary

This chapter has discussed the structure and operation of the model and has examined the important mission entry and scheduling functions. Special features which help to give the model its flexibility were also outlined. The next chapter will discuss the verification and validation process which was employed during model construction.

V. Verification and Validation

Overview

The previous chapters have discussed the process of conceptualization and construction of the model. This chapter will outline the process used to check that the model was performing as constructed and that it accurately reflected the system under consideration.

Verification vs Validation

Verification. In a strict sense, verification can be defined as insuring that the model is performing as designed and validation that it accurately reflects the system in question. In reality, the two processes are intermixed. While verification (which includes "debugging") usually lends itself to relatively concise, objective treatment (such as checking percentages and tracing model operation), validation is more subjective and essentially consists of comparing model performance to "real-world" data or experience. One aspect of the testing process for this model should be noted: it was assumed that intrinsic SLAM functions (such as network switching, random variate generation, and various utility routines) performed as specified. However, performance of the various FORTRAN routines, subnetworks, and network sections such as the crew-change activity were carefully examined. Thus, no attempt was made to directly verify the performance of the language itself.

Validation Considerations. In some cases, the system being simulated has not operated under the conditions modeled or perhaps does not yet exist. In such instances, validation might well consist primarily of insuring that model performance is

"credible". For the Alaskan system, this case is applicable, since the system has never been fully exercised under wartime conditions. In a larger sense, validation includes insuring that the pieces which form the model, as well as the way in which these pieces are assembled, are sufficiently realistic to promote confidence in the final product. This process begins at the very earliest stages of conceptualization and continues through selection of model structure and methods for treating various model components. Indeed, this process is almost an unconscious one and is an integral part of decisions and assumptions affecting model development. This aspect of validation has largely been covered in previous sections; accordingly, this chapter will primarily outline the "conscious", preplanned aspect of validation for this model.

Construction Stages

Verification and validation were made easier by building the model in stages, with each stage representing a reasonably well known aspect of present system operation. Each stage could be verified and validated before continuing model construction. Once the final model was assembled, the various components again needed to be checked in the overall context. At all stages, the model output was compared to the results of selected exercises to insure that model results were reasonable. Thus, verification and validation were simultaneous processes during model construction.

Forward Airhead Model. The first stage of development was a small-scale G-GERT simulation of the bare-base forward airhead, based on the Granite Mountain airhead operated for ARCTIC CIRCLE 80. This model was tested with various combinations of input flow rates, cargo mixes, traffic restrictions, and PME configurations.

It showed that the maximum usable flow rate was about three arrivals per hour and that traffic restrictions (a one-way runway and severe MOC limitations) were major limiting factors. This data accurately reflected actual operational experience during the exercise, and so the forward airhead "sub-model" was accepted as satisfactory. (This model was subsequently translated to SLAM.)

Initial Main Base Model. Next, a SLAM main-base model was constructed which incorporated all major features except the continuation check and the scheduler. The offload, maintenance, and onload functions were then tested against a various streams of missions to determine average ground times and maintenance downtime. These figures were reasonable and were of the same magnitude as home-base figures experienced during high-flow exercises at Elmendorf.

Closed-Loop Test. After a model for a forward-area fighter alert and staging base was developed and checked against "real-world" experience at Galena and King Salmon, a two-base model consisting of the main base and the staging base was built. This model circulated aircraft in a closed loop and included a rudimentary scheduler which operated under the flow rate limitations of the staging base in order to check the important flow-regulation concept. Additionally, the crew change facility was included at the main base and crewday limitations were imposed.

Mission times with various load types were checked and found to be quite close to those actually experienced by the author: for instance, the model showed that one crew could make about three round trips in a single crew day, which was a commonly accepted figure used by exercise planners at Elmendorf, and which represented a combination of all factors involved in the shuttle.

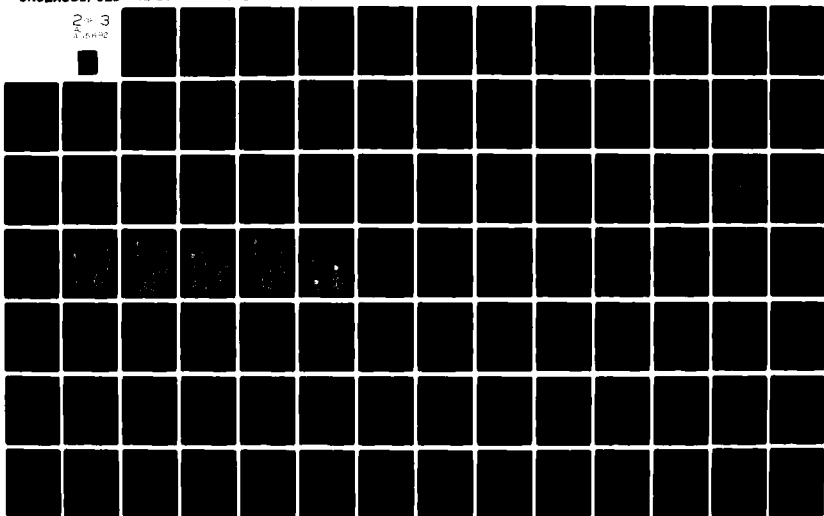
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Likewise, closure times for various mission streams reflected actual experience: a 20-mission move to a base similar to Galena could be closed in 16 to 20 hours using six airplanes and ten crews under average conditions, with one or two aircraft eventually dropping out of the flow for extended maintenance; model results were very similar. Of equal importance was that the flow-regulation mechanism worked as designed and could be relied upon to duplicate the actual command-post controller's function of preventing "waves" of aircraft from overwhelming forward base facilities. Since the "real-world" data was far from exact and represented little more than planning factors based on experience, rigorous statistical verification was useless; this is an example of the "reasonableness" approach to verification and validation which was used extensively for this model.

Final Model Testing

In a multibase theater airlift model, testing of the assembled model can be complicated because of the many possible situations which can arise during the course of model operation. Testing of the Alaskan model was accomplished primarily by running the model with known mission inputs designed to exercise each component of the model. With the various print/trace features enabled, these mission streams were thoroughly traced through the system. With the use of the CYBER EDITOR feature, output from a run could be examined very quickly: for instance, all occurrences in the output referencing a particular mission number could be displayed, resulting in a concise chronological trace of that mission through the system from initial entry to completion. Similarly, all entries for a particular aircraft number could be displayed, allowing individual aircraft to be easily followed.

This procedure allowed very rapid debugging, verification, and validation of the model's performance under many different operating regimes.

Scheduler Testing. Since the scheduler is by far the most complex aspect of the model, it was provided with its own separately controlled internal tracing system. With XX(87) set to 9 (the deepest level of examination), every facet of the scheduler's operation could be observed, to the extent that one scheduling event could consume more than 100 lines of output. For instance, flow regulation to forward airfields with limited capacity was crucial to the proper operation of the model. To test it in the assembled model, the REP subroutine was used to provide a stream of missions to Base 4 (the bare-base forward airhead). With the scheduler trace set to level 9, every check of the file of already scheduled estimated times of arrival (ETAs) was printed, and the scheduler's actions could be precisely checked. As each feature of the scheduler was verified to be operating properly, the depth of examination was decreased by setting progressively lower levels for XX(87). When satisfied that the scheduler was functioning properly under a wide range of possible conditions, the scheduling trace was switched off for the remainder of the testing process. (For clarity of documentation, all but the key scheduler trace elements have been edited out of the SCHED listing in Appendix E.)

Aborts. Special treatment was also given to the abort feature of the model. Although aborts (both ground and enroute) have a considerable effect on system performance, they are one of the most difficult aspects to treat realistically because of the many combinations of location, load type, and stage of mission completion which must be accounted for. Since inclusion of aborts

was one of the several features of the Alaskan model which differentiated it from previous theater models, the author considered it important to insure proper functioning of the system in this respect. The testing process for aborts was twofold and consisted of ascertaining that aborts were being triggered at the proper times and in the proper proportions, and of insuring that the aborts were properly handled and routed once generated.

To test the former, the abort rates previously discussed were temporarily quadrupled (to a maximum 20% overall) to force the model to generate many aborts. Several varied mission streams were then introduced which exercised all of the model features connected with the abort process. The numbers of aborts being generated by the various trigger mechanisms (shutdown, start, and enroute) were then compared with total sorties flown to give percentages, which were then checked against the desired abort rates. The rates were found to be within plus or minus one percent of desired for the three components, thus indicating that the abort triggering mechanisms were functioning as designed.

The subsequent handling of aborted aircraft and missions was somewhat more complicated to check and required much tracing of individual missions to insure that loads were properly restructured and offloaded and that aborted aircraft were correctly routed and given required maintenance on return to home base. In this manner, a few abort situations were identified which had not been originally included; the network and FORTRAN code were adjusted to reflect these new conditions. It should be noted that much of the FORTRAN code in the abort-connected subroutines (CONTIN, RESTRT, ENRTE, APPRCH, CMETX, RESCUE, and RESCH) is given over to identification and handling of the various abort situations. This code was intentionally made as transparent

as possible and was very heavily documented to insure that the abort process -- a major feature of the model -- can be readily followed.

Significant Problems

As might be expected, some problems were unearthed during this extensive testing program. In particular, some facets of model operation disclosed unanticipated effects. Three of these -- what the author will refer to as the "block-scheduling" problem, the preloading" problem, and the "degraded-aircraft" problem -- merit discussion.

The "Block-Scheduling" Problem. The block-scheduling problem was discovered when many missions with similar priorities and ready times were entered at Base 1 and Base 2. Since both bases are originating points for battalion moves (two battalions at Fort Richardson and one at Fort Wainwright), and since most of these missions tend to become available for movement nearly simultaneously, there is a need to insure that some airplanes are allocated to each group of missions. Test runs quickly disclosed that since all aircraft ultimately returned to Elmendorf, the scheduler would try to exhaust all missions at Elmendorf before it would begin to schedule aircraft against the loads waiting at Fairbanks.

To force the scheduler to allocate aircraft in a more realistic fashion, two solutions were implemented. First, the scheduler was made to check missions waiting at both bases and to begin the scheduling process at the base with the highest priority mission. If priorities were equal, the scheduler would use the oldest ready time as a tie-breaker. Additionally, the mission input was differentiated to promote this equal allocation by using

slightly different priorities and ready times for blocks of missions. This had the added benefit of insuring that all missions in a particular block of missions with, say, priority 2 and ready time 3720 (which could be the personnel movement for an infantry company), would be moved before a block of missions with priority 2 and ready time 3725 (which could be that company's follow-on equipment and supplies). Similarly, the missions for different units could be structured to insure proper sequencing of moves from different bases. This solution, while artificial, very closely represents the decision process which actually occurs when a great number of missions with "inflated" priorities are simultaneously dumped into the system.

The "Preloading" Problem. In the course of testing the model with a set number of crews and a varying number of aircraft, it was found that closure times would decrease as more aircraft became available (as expected). However, instead of leveling off at a minimum figure once the number of aircraft began to exceed the number of crews, closure times began to increase. The problem was determined to be caused by the scheduler's assigning of missions to "non-crewed" aircraft, which would then wait for crews (sometimes for very long periods). While these "pre-loaded" aircraft were waiting for crews, aircraft in the system would return to home base with sufficient crew time remaining to pick up a new mission. The inbound crew and aircraft would often find no unassigned missions; the crew would be returned to crew rest and the aircraft would be placed in the hold loop, wasting usable crew day. In practice, aircraft are not pre-loaded in this manner and the problem does not occur; accordingly, the scheduler was modified to insure that aircraft at home base needing new crews to begin missions would not be scheduled unless a rested crew was readily available.

The "Degraded-Aircraft" Problem. As discussed in Chapter III, non-tactically capable aircraft normally are not allowed to undertake tactical missions. In peacetime, this policy works well, since there is no need to risk the problems which might occur if, say, an aircraft with an inoperative antiskid braking system were to attempt an assault landing on a short runway. If necessary, however, such landings can usually be safely made without antiskid; in some cases landings can even be made without brakes, thanks to the excellent deceleration and steering control provided by the reversible propellers. (This is one of many instances in which the C-130's versatility can allow emergency performance well in excess of peacetime limitations.) Since many missions in the Alaskan theater (including all forward-airhead missions) theoretically require fully capable aircraft, the model was discovered to be not scheduling FMC aircraft after all FMC missions had been accomplished. This resulted in closure times becoming very much longer than would be anticipated, since aircraft in FMC status would not be scheduled and thus would not be recycled through maintenance, eliminating any possibility for them to regain FMC status. In some cases, all aircraft eventually became FMC, thus stopping the flow.

Even in peacetime, non-tactical aircraft are allowed to undertake some tactical missions if safety can be assured, and in wartime it is unlikely that any aircraft would stand idle if there were even a reasonable chance that it could accomplish a mission. Thus, it is safe to assume that although the tactical vs non-tactical distinction would be adhered to when practical, non-tactical aircraft would eventually be scheduled if required. Thus, the model was changed to allow a non-tactical aircraft a

50-50 chance to return to maintenance from the scheduler if no suitable mission were found. Combined with the 50% rate of return to FMC once in maintenance, this allowed a FMC aircraft an average 25% chance to return to fully capable status each time it could not be scheduled. This was considered to be a reasonable representation of the eventual forced use of FMC aircraft in a wartime situation, and did in fact restore closure times to reasonable ranges.

Summary

Overall, the verification and validation process was as thorough as possible for a model of this type and complexity. As expected, the process was sometimes complex as the model was pushed into situations not originally envisioned. Most important, however, is that each step forward was made from a known level of performance which allowed a basis for comparison of results. Accordingly, the author is reasonably certain that the final model realistically reflects at least the nature of the interactions within the Alaskan airlift system, if not their exact magnitude. The next chapter will show how the finished model was used to analyze basic aspects of system operation.

VI. Analysis

Overview

Previous chapters have discussed the construction and testing of the model. This chapter will discuss the use of the model for analysis. However, complete analysis of any theater airlift system could consume months or even years, and it is not the purpose of this thesis to conduct such an exhaustive examination. Rather, a "baseline" analysis will be conducted for a representative mission input under controlled conditions to gain an initial insight into the system's performance. This will also serve to demonstrate the use of the model for analysis and to provide the groundwork for further, more extensive research. The analysis will consist of two separate parts: the first will be a screening experiment designed to quickly analyze many likely factors for significant effects on the output; the second will be a more detailed analysis of the two most important factors thus discovered.

Analytical Considerations

Comparative vs Predictive Use. The Alaskan airlift model, like others of its kind, is subject to certain limitations when used for analysis. First, the model is designed primarily to examine effects and interactions of various factors affecting the system, and is not intended to precisely predict such output measures as closure time. Although the model will provide an estimate of closure time for a given mission stream, this estimate may or may not be accurate for predictive purposes. When compared with closure times generated under different conditions, however, this time will be useful for estimating relative effects. It must

be remembered that the assumptions upon which the model is based reflect a projected wartime operational mode in which the system has not yet been tested. As actual exercises become more realistic and a larger data base is built, the model's predictive ability could be examined and possibly validated. For the present, however, the model's reflections of system performance should be used only for comparative purposes, and while "reasonable", these measures should be carefully examined before the model is relied upon for forecasting.

Variability of Conditions. Second, system performance can vary greatly depending on the mission input, and conclusions drawn from runs with a particular input might not be applicable to a different situation. For instance, results of an analysis based on a simultaneous two-battalion move may not be accurate when applied to two single-battalion moves a week apart and to different locations. This is not necessarily a drawback to the model; rather, it reflects the highly variable nature of theater logistics systems in general and points out the inherent care which must be exercised in their analysis.

Importance of Experimental Design. Lastly, careful experimental design is mandatory to insure that this model (or any other of its type) will give meaningful results. It is very possible to set parameters for system operation which will either stop the flow altogether or which will give data which is useless for organized analysis. A high threat situation in the forward airhead zone, for instance, will result in the ultimate loss of all aircraft in the system if all missions are of the "must-fly" risk category. This, in turn, demonstrates nothing except that airlift aircraft suffer very high attrition in high-threat areas, and the closure times (if any) which are gained from such an

exercise have virtually no comparative value. (Loss of aircraft without replacement, as in this model, results in a combinatorial situation which induces very great variance in results.) While it is easy to drive the model into extreme situations (just as with the real system), the results of such actions would not normally be of analytical value. Thus, the model is most useful when used for analysis of situations within the realm of probability; "unreasonable" situations will almost always produce "unreasonable" results.

Outline of Analysis. Based on these premises, the model was used for an analysis of system performance in a representative situation. First, a mission input roughly typical of a simultaneous two-battalion move (with supporting equipment) was constructed. Next, a number of factors which could be expected to affect this flow were selected and screened (via a fractional factorial screening design) to determine which were significant enough to warrant further examination. Finally, the two most significant factors were examined in depth (using a factorial design and graphical analysis) and conclusions drawn about the system's performance under the given conditions.

Scenario and Mission Input

A typical scenario for several command-post exercises in which the author participated involved the rapid commitment of two battalions and supporting artillery, airmobile, and support assets against an enemy incursion at a western or southwestern Alaska location. Accordingly, the mission input was constructed to roughly approximate this situation, which could be considered representative of expected theater wartime operation. First, data file MSTACK was created, containing the bulk of the missions

to be input; MSTACK is listed (with explanation of missions) in Appendix C. Next, subroutine REP was restructured to enter three resupply missions each eight hours, representing day-to-day logistics missions which could be expected to continue even in wartime; the listing of subroutine REP in Appendix B reflects this configuration. During the course of the simulation, missions were entered at their respective ready times either by subroutine STACK, which read data file MSTACK, or by subroutine REP, which created missions internally. Once all missions were entered from MSTACK, mission input from REP was automatically ended, thus insuring that mission input for each run was identical in both time and composition.

Once REP had been structured as required, the entire model FORTRAN source code (including all subroutines) was recompiled (using FORTRAN V) and stored as binary object file MAIN. For use on the CYBER, files MSTACK and MAIN were stored using the NOSFILE Indirect File Library under file library identification "DB". These files were then recalled by the batch control deck for use by the SLAM program during execution. The control card deck used to set up the model for execution is listed at the beginning of the SLAM network listing in Appendix A. All missions could have been included in MSTACK if desired; REP was used primarily to demonstrate the use of this alternate input mode. Exclusive use of the MSTACK entry mode obviates the need to restructure and recompile the FORTRAN source code when changing the REP mission input.

Screening Experiment

Design Considerations. With the mission input determined, the screening experiment could be constructed. First, it was

necessary to determine which factors were to be examined. Some factors, such as the weather in zones not used for the mission flow, would obviously not have any effect on system performance; these factors could be immediately eliminated from consideration. Conversely, some factors would have too great an influence on system operation and could mask or skew the effect of the factors of interest; this consideration is important in a "first-cut" screening experiment where extreme situations are not desired. As previously mentioned, attrition can cause serious variance problems; accordingly, the threat input was defaulted to "no threat" to prevent attrition from affecting the analysis. (Some runs were subsequently made to examine attrition; these will be discussed later in this chapter.) This "common-sense" elimination process ultimately left 15 factors for screening.

Fractional Factorials. Since this experiment was intended only to identify significant effects for further investigation, a two-level factorial design was considered appropriate. Such a design can measure linear effects and will satisfactorily detect quadratic and higher-order effects, and thus is well suited for screening purposes. A full two-level factorial in 15 variables, however, requires 2^{15} (or 32768) runs; thus, various fractional factorial designs were considered. Fractional factorials can examine up to (but not quite) one factor per run; however, this economy is purchased at the price of "confounding". (For a full treatment of experimental design, see Montgomery, Refs 12 and 13.)

Confounding. Essentially, confounding (also called "aliasing") is the combination of several effects into one effect which can then be readily analyzed. If it can be assumed (as it usually can) that most of the higher-order interactions are negligible, then confounding these effects with the effects of

interest will still yield meaningful results. In practice, interactions of the third order and higher are considered negligible except in very special cases. Aliasing of first and second-order effects can then be very selectively controlled through the design of the fractional factorial experiment. A Resolution III fractional factorial design aliases primary effects with second-order effects, but can handle up to $N-1$ factors in N runs. Thus, if second-order effects could be neglected, 15 factors could be examined in only 16 runs. If some factors are anticipated to have large effects, however, second-order interactions may be important and thus a Resolution IV design might be more desirable. Such a design needs twice as many runs as a comparable Resolution III design (32 runs for 15 factors, for instance), but since it only aliases primary effects with third-order and higher effects, it can provide "clear" estimates of the first-order effects for all factors. Even though some second-order effects are aliased with other second-order effects, careful design can insure that the second-order interactions of very active factors are not aliased with each other. This requires some foreknowledge of which factors are most likely to be significant, but such information is frequently available.

Screening Experimental Design. For this 15-factor experiment, a Resolution IV design requiring 32 runs was chosen. A major reason for this was the expected large effect of three factors: number of aircraft, number of crews, and crew day length. Care was taken to insure that the second-order interactions involving these factors (aircraft-crews, aircraft-crew day, and crews-crew day) were aliased only with second order effects which were not expected to be of great importance. (This is most easily done by placing the few most

active factors in the "primary" positions in the design -- i.e., the positions they would occupy if the design were to be a full factorial without confounding.)

Care must be exercised in the choosing of the two levels for each factor to insure that all effects will be represented; normally, this means setting the factors under consideration at or near the limits of their probable ranges. By convention, these levels are designated (-) and (+). For instance, the (-) level for aircraft for the Alaskan model was set at 10 and the (+) level at 40, representing the approximate lowest and highest number of aircraft which could be expected to be available in Alaska. In order to extract the most value from a fractional factorial design, some knowledge of the anticipated direction of effect for each factor is of great value. For instance, an increase in the number of aircraft or aircrews in the Alaskan model could be expected to have a beneficial effect on the output measure -- in this case, a shorter closure time. Although the allocation of "positive" and "negative" levels is strictly the analyst's choice, this allocation should be consistent if at all possible: moving from the (-) to (+) level of any factor should result in a decrease in closure time, for example.

Once the factors and their levels were chosen and the final design built (Table IV), the SLAM network listing was modified to cause 33 runs to be made. (Throughout the analysis, the model was allowed to make the first run of any multiple-run batch at default parameters in order to provide a benchmark for proper model operation.) For each of the 32 design runs, the factor levels were reset via INTLC statements to reflect the (-) or (+) levels indicated in the design. All 32 design runs were thus accomplished in one batch job by the single network listing -- a

TABLE IV: SCREENING EXPERIMENT FACTORS AND DESIGN

RUN RESULTS ARE IN MINUTES FROM START OF SIMULATION

FACTOR			SLAM VRBL	(-) LEVEL	(+) LEVEL
A	AIRCRAFT	XX(1)	10	40	
B	AIRCRAFT	XX(2)	15	50	
C	CHWDAY	XX(10)	720 (12 HOURS)	860 (10 HOURS)	
D	SEASON	XX(31)	3 (WINTER)	1 (SUMMER)	
E	WEATHER	XX(34)	2 (VARIABLE)	1 (ALL CLEAR)	
F	NOG3	XX(63)	4	10	
G	NOG4	XX(64)	2	3	
H	ATC3	XX(68)	1	2	
I	ATC4	XX(69)	1	2	
J	FX3	XX(73)	1	4	
K	FX4	XX(74)	1	2	
L	K3	XX(78)	0	1	
M	K4	XX(79)	0	1	
N	APP3	XX(83)	1 (NONPRECISION)	2 (PRECISION)	
O	APP4	XX(84)	0 (VFR ONLY)	1 (NONPRECISION)	

NUM		FACTOR												RESULTS			
NO		A	B	C	D	E	F=ABC	G=ABD	H=ABE	I=ACD	J=ACE	K=ADE	L=ABCD	M=ABCE	N=ABDE	O=ACDE	
1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13945
2		+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14240
3		-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	11430
4		+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	7001
5		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	11070
6		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	11355
7		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10730
8		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8011
9		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	14310
10		+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	12015
11		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10725
12		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8765
13		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10825
14		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	11000
15		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10105
16		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8070
17		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	13300
18		+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	13140
19		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10705
20		+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	7005
21		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	11415
22		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10710
23		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	11000
24		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8000
25		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	12775
26		+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	12000
27		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10115
28		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8741
29		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10005
30		+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	10475
31		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	10100
32		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	8793

much easier (and considerably less costly) method than making 32 individual runs. The SLAM network listing in Appendix A reflects the setup used to accomplish this screening design.

Screening Results. With the run results from the screening experiment in hand, the search for significant factors could begin. First, the estimated effects for all factors were computed using the contrast method. For each factor, the corresponding column of (+) and (-) signs was used as a guide for totaling the 32 run results: a (+) sign indicated that the particular run result was to be added, a (-) sign indicated that it was to be subtracted. This total was then divided by 16 (32 runs divided by 2) to yield the estimated effect for the factor in question. Contrasts were also set up for the second-order effects by multiplying the two concerned columns together as if the (+) and (-) signs were +1 and -1, respectively. Thus, the proper sign for run 1 for the aircraft-crew (AC) contrast was $(-)*(-)=(+)$, and so on for each run and each desired interaction. The two-factor effects were then found similarly to the main effects. The computed effects are shown in Table V.

Table V. Effects of Factors (in Minutes)

Factor	Effect	Interaction	Effect
A - Aircraft	-2088	AB - Aircraft/Crews	-1712
B - Aircrews	-3487	AC - Aircraft/Crew day	+40
C - Crew day	-1287	AD - Aircraft/Season	+108
D - Season	-578	AE - Aircraft/Weather	+87
E - Weather	-488	BC - Crews/Crew day	+1088
F - MOG3	+23	BD - Crews/Season	+52
G - MOG4	+154	BE - Crews/Weather	+288
H - ATC3	+38	CD - Crew day/Season	+2
I - ATC4	+228	CE - Crew day/Weather	+184
J - FK3	-174	DE - Season/Weather	+27
K - FK4	-125		
L - K3	-148		
M - K4	-27		
N - Inst App 3	-55		
O - Inst App 4	-88		

Normal Probability Plot. To quickly and graphically indicate the significant effects, a normal probability plot was used. This is based on the assumption that the non-significant effects should follow a normal distribution; when properly plotted on normal probability paper, these "background noise" effects will tend to form a straight line, while significant effects will fall far from the line. To make the plot, the 25 first- and second-order effects computed above were rank-ordered greatest to least. A probability was then computed for each using the formula

$$P = (J - .5) / N$$

where J = the numerical rank of the effect (1 through 25), and N = the total number of effects to be plotted (25). The magnitude of each effect was then plotted against its probability.

As can be readily seen in Figure 8, the resulting plot showed that the aircraft, crew, and crew day effects were unquestionably significant, as were the aircraft-crew and crew-crew day interactions. Thus, further examination of these three factors was definitely indicated. The season and weather effects appeared to be significant, but required further examination. Accordingly, a five-way ANOVA using the 32 run results was conducted using the SPSS (Statistical Package for the Social Sciences) ANOVA routine. Since season and weather were initially anticipated to have significant effects, they were placed in "primary" positions in the screening design; this allowed the original screening design to be "collapsed" into a single replicate of a two-level, five-factor full factorial design incorporating all five potentially active factors; this, in turn, could be directly analyzed using the ANOVA program. As can be seen from the ANOVA printout in Table VI, season and weather were in fact significant, although to a much lesser degree than aircraft, crews, and crew day.

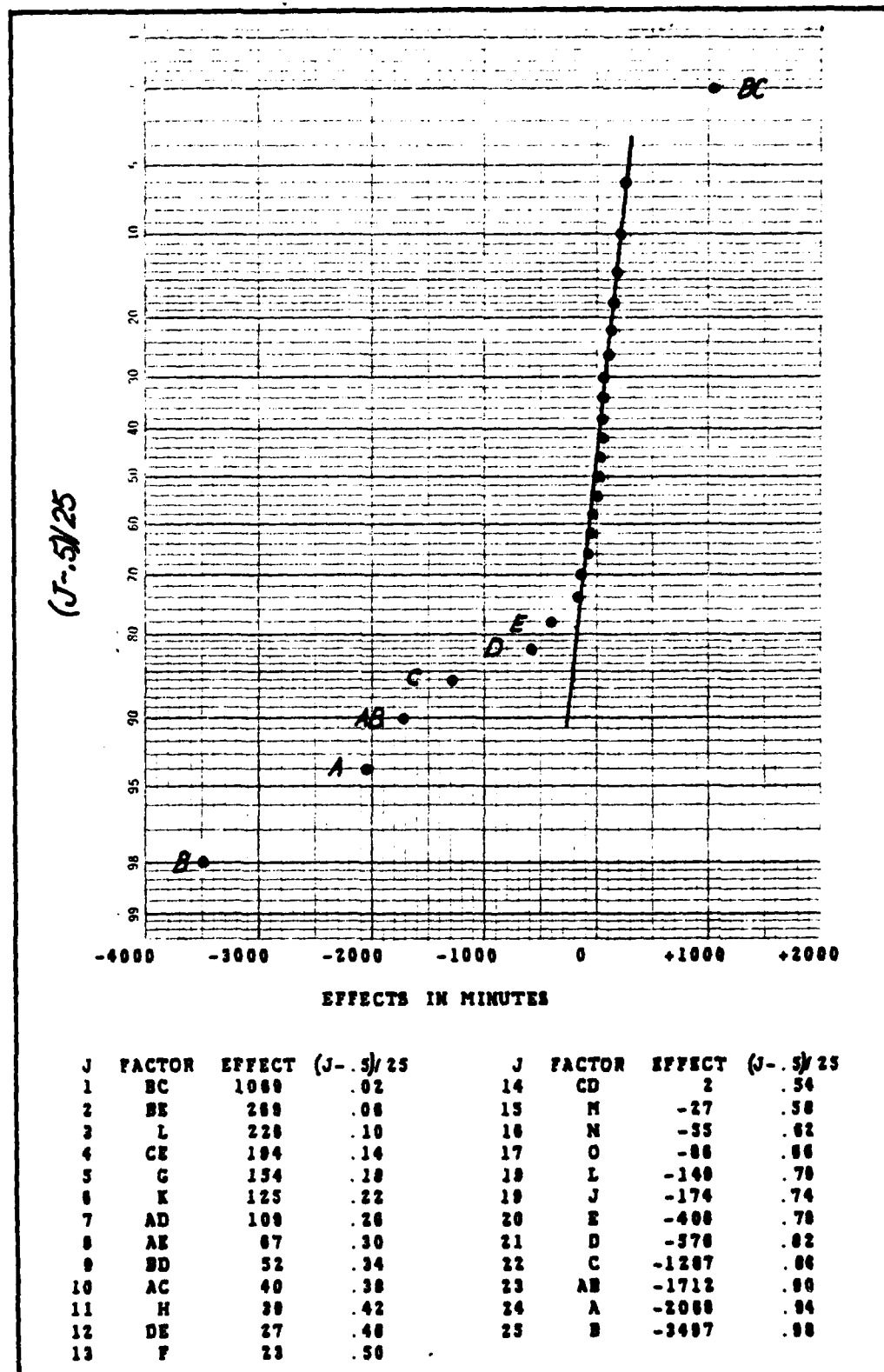


FIGURE 9: NORMAL PROBABILITY PLOT

TABLE VI: FIVEWAY ANOVA

***** ANALYSIS OF VARIANCE *****

CTIN
 BY ACFT 1=10 ACFT, 2=40 ACFT
 CREWS 1=15 CREWS, 2=50 CREWS
 CDAY 1=12 HRS, 2=18 HRS
 SEASON 1=SUMMER, 2=WINTER
 VX 1=VARY, 2=NONVARY

(*) DENOTES SIGNIFICANT EFFECT AT 1%

(+) DENOTES SIGNIFICANT EFFECT AT 5%

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	.14075E+00	5	.2815E+00	315.872	.001
* ACFT	34221204.500	1	.3422E+08	369.331	.001
* CREWS	97825078.125	1	.9782E+08	1038.621	.001
* CDAY	13258100.500	1	.1325E+08	140.742	.001
* SEASON	2132145.125	1	.2132E+07	22.848	.001
* VX	1328312.500	1	.1328E+07	14.018	.002
2-WAY INTERACTIONS	33638677.000	10	.3363E+07	35.715	.001
* ACFT CREWS	23447552.000	1	.2344E+08	248.845	.001
ACFT CDAY	12888.125	1	.1288E+05	.137	.718
ACFT SEASON	84178.000	1	.8417E+05	1.000	.332
ACFT VX	38315.125	1	.3831E+05	.388	.543
* CREWS CDAY	8142688.000	1	.8142E+07	87.083	.001
CREWS SEASON	21845.125	1	.2184E+05	.233	.630
+ CREWS VX	577812.500	1	.5778E+06	6.135	.025
CDAY SEASON	40.500	1	.40E+00	.000	.984
CDAY VX	288825.125	1	.2888E+06	3.104	.083
SEASON VX	5848.500	1	.5848E+04	.062	.805
EXPLAINED	.18238E+00	15	.121E+00	128.100	.001
RESIDUAL	1567888.125	16	98107.500		
TOTAL	.18398E+00	31	.593E+07		

32 CASES WERE PROCESSED.

9 CASES (0 PCT) WERE MISSING.

Aircraft/Aircrew Analysis

Factor Selection. Although the screening experiment disclosed that five factors exercised significant effects on closure time, it could give little indication of the nature of these effects. Moreover, the presence of very strong second-order interactions between aircraft, aircrews, and crew day indicated that complex and probably nonlinear relationships might be involved. Since season and weather, although significant, had relatively weak effects, further analysis was directed toward aircraft, crews, and crew day. To simplify this analysis, it was decided to treat the crew day factor (which was much the weakest of the three) as a fixed parameter. Since wartime crew day limits would probably be closer to 16 hours than to 12 hours, the higher figure was chosen. In any case, it was logically assumed that a shorter crew day would substantially increase the closure time for a given combination of aircraft and aircrews.

Experimental Design. The analysis was thus centered upon the two most significant factors -- numbers of aircraft and aircrews. In order to explore all likely combinations of the two, a factorial design was chosen. Aircraft levels were set at 10, 15, 20, 25, 30, and 40, while aircrews were set at 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60. These levels covered the most probable ranges of both factors in Alaska and were expected to provide a "response surface" with enough definition to allow conclusions to be drawn about the nature of the effects and their interactions.

To try to show the aircraft/aircrew effects as clearly as possible, the system was allowed to operate freely, with good weather, no threat, and round-the-clock operation. Forward base parameters were set at approximately the levels used in the ARCTIC

CIRCLE 80 exercise. These conditions were expected to provide a "best-case" benchmark which could be used to more accurately estimate the effects of other factors in future investigations.

The data was secured using much the same procedure as for the screening experiment. The SLAM network listing was modified to make 61 runs (a default run and 60 data runs), with aircraft and crew levels for each run being set by appropriate INTLC statements. In order to provide a better data base, three 61-run batch jobs were made. Each group of 60 data runs was made with a separate random number seed, which was inserted at the beginning of the first data run via a SEEDS statement. Once set, random number seeds were not re-initialized between separate runs. Since any change in the aircraft/crew combination would result in a different number of calls on the random number stream, each individual run was thus assured of a "separate" random number stream. The three-run averages for each cell are shown in Table VII.

Variance Reduction. It should be noted that the model was constructed to use only one random number stream. Since the model makes thousands of calls for random numbers in the course of a single run, and since correlation of these calls between runs was impossible, the use of antithetic random numbers for variance reduction was ruled out. Although it may have been possible to provide correlation for certain isolated features (such as the weather subroutine, which makes a set number of calls every six hours), the complexity required was not judged worth the marginal results which were anticipated. In any case, the use of a fixed mission input was found to be a very effective variance reduction technique for this model.

TABLE VII. AIRCRAFT/AIRCREW ANALYSIS RESULTS

CLOSURE TIMES IN MINUTES
(EACH CELL IS A 3-RUN AVERAGE)

NUMBER CREWS	NUMBER OF AIRCRAFT					
	10	15	20	25	30	40
10	15050	14883	14943	14967	14783	14883
15	10780	10677	10730	10510	10440	10523
20	10187	8895	8887	8979	9113	9142
25	10088	8336	8147	8050	7836	8112
30	10006	8198	7594	7721	7671	7650
35	8968	8221	7537	7418	7571	7474
40	10071	8191	7203	7140	6973	7112
45	10063	8124	7294	6921	6743	6778
50	8925	8057	7377	6843	6796	6816
60	10028	8212	7572	7054	6800	6835

Graphical Analysis. Once the data was organized and the cell averages computed, a pattern immediately emerged: the closure times decreased (but at different rates) as aircraft and crew levels were increased. More importantly, the times appeared to "level off" at well-defined minimums, which were different for each factor level. Since this indicated that the relationship between the two factors might be very complex, a graphical presentation was undertaken in an attempt to keep the effects as easy to visualize as possible. Accordingly, the graph in Figure 10 was constructed by plotting each level of aircraft as a separate line against closure time. (A similar graph could have been obtained by plotting crew levels as separate lines.)

Nonlinearity of Effects. As can be seen in Figure 10, the nature of the interaction between the aircraft and crews is immediately obvious and very well defined. Several features of this interaction would be of great use to an operational planner. First, it is apparent that application of more resources does not have a linear effect on closure time. In fact, the relationship appears to be nearly exponential, and decrements in closure time become increasingly more costly as the ultimate limit of approximately 6500 minutes is approached. (The last missions were entered at T=6000 and required about 500 minutes to complete if scheduled immediately.)

This marked departure from the linear can be assumed to be due to the cumulative effect of system delays. For instance given ten missions to be accomplished, ten aircraft could close the flow in about the time required for one mission to be accomplished (plus saturation delays). Five aircraft, however, would require more than double this time due to the additional "turn time" between missions. For even fewer aircraft, these delays would

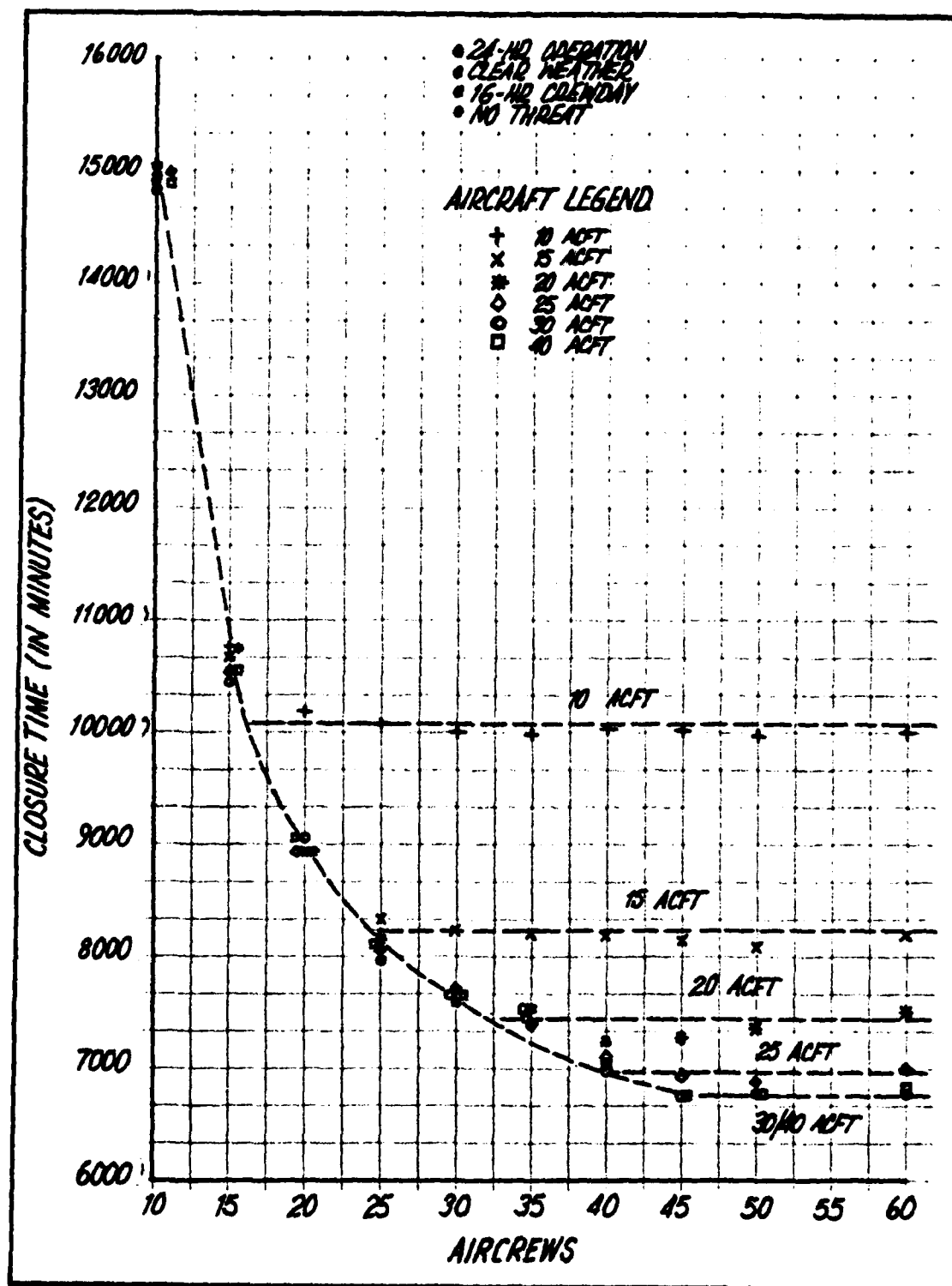


FIGURE 10: AIRCRAFT VS AIRCREWS VS CLOSURE TIME

accumulate, especially for crew rest and extended maintenance. For very large flows (such as the one under consideration) this accumulation will eventually "smooth out" into the non-linear relationship shown in Figure 10.

Operational Value of Analysis. This relationship would be of immediate concern to an operational planner concerned with force sizing or with estimating existing capabilities. For instance, a planner would have to make a value judgment about decreasing the closure time from, say, 8000 minutes to 7000 minutes (a change of about 18 hours) if it would require nearly doubling the number of aircraft and crews required. However, the decision-making process would be much clarified if a graph (or series of graphs) similar to Figure 10 were available. For the Alaskan system, it would seem that allocation of more than 20 to 25 aircraft to a flow of this type (and under these conditions) would not be productive.

Optimum Aircrew/Aircraft Manning. Examination of the line for each aircraft level shows another interesting feature. For a given number of aircraft, closure time can be decreased by adding crews, but only to a certain point; beyond this point, additional crews have no effect. In effect, the transition from the curve to the horizontal represents a "break point" for a given number of aircraft: with fewer crews, the flow is crew-limited; with more crews, it is aircraft-limited. Thus, the horizontal lines for the various numbers of aircraft represent the best possible closure time which can be attained for that number of aircraft, regardless of numbers of crews. Conversely, the curving line represents the best possible closure time which can be attained from a given number of crews, regardless of number of aircraft. For each aircraft level, the point at which the aircraft-limited portion

intersects the curve (the crew-limited portion) can be considered an optimum -- more crews would be wasted, while fewer crews would cause closure time to increase. The ratio of crews to aircraft at these break points is approximately 1.6, which would indicate to the planner that this would be the optimum crew ratio for execution of the given flow under the given conditions. As a matter of interest, most C-130 units are manned at a 2.0 crew-to-aircraft ratio, while Alaskan assigned forces are manned at 1.5; thus, the 1.6 figure, which represents a "best-case" situation, might seem to indicate that Alaskan airlift forces are undermanned.

Crewday Considerations. It is also possible to estimate the nature of the effect of crew day length, given Figure 10. Since a given number of aircraft will eventually reach a maximum-utilization limit beyond which additional crews are of no consequence, it is reasonable to assume that the "best possible" closure time for a given number of aircraft (at least in the central region of the graph) would remain unchanged if a 12-hour crew day were to be imposed. However, the crew-limiting curve would shift upward, resulting in a changed "break point" for each number of aircraft. This, of course, would result in an increase in the optimum crew-to-aircraft ratio. At the lower right portion of the graph, the "absolute best" closure times obtained by the highest levels of aircraft and crews might well increase, since very great numbers of crews may be required and even these large aircraft forces might become crew-limited. (Since the Alaskan theater would be most fortunate to see even 30 usable aircraft, analysis of effects in this portion of the graph may be academic.)

Effects of Other Factors. Effects of other factors on the aircraft/crew interactions would probably vary in intensity, but

would most likely serve to move the graph upward; both the crew-limiting curve and the best-time lines would probably increase in varying amounts, with resulting changes in the optimum crew ratio. It is probable, however, that the general structure of the graph would remain largely unchanged -- a roughly exponential crew-limiting curve with horizontal aircraft-limiting lines. This conclusion has been tentatively verified by plotting the run results from the screening experiment on Figure 10; however, the shifting caused by other factors seems to be much more pronounced at the smaller force levels. Exploration of the effects of other factors on the crew/aircraft curve is, of course, a subject for considerable further study.

Attrition

To test effects of attrition against known results, runs were with 20 aircraft and 25, 30, and 35 crews. The risk level in Zone 6 (the forward airhead) was forced to the high-threat condition (threat present with low clouds and no escort). All other conditions were as for the main aircraft/crew analysis. Since all forward airhead missions in the input flow were "go-at-all-cost" missions, aircraft were thus forced to fly into (and out of) the high-threat area on each trip to the forward airhead. With the high-threat attrition rate set at 10%, no flows were completed; in fact, all aircraft were destroyed by about T=15000 in every run. The attrition rate was then lowered to 3%; some flows were completed by model shutdown at T=20160 (two weeks), but the completion times had extremely wide variances due to the combinatorial nature of nonreplaced aircraft loss; in fact, the closure times ranged from about 9000 minutes to more than 16000, depending on the number of aircraft lost and the time of loss of

each. Crew ratios seemed to have little effect on the closure times; indeed, as each aircraft and its crew was lost, the flow became more and more aircraft limited, thus tending to eliminate the crew effect completely. Overall, the variance with attrition was so extreme that no meaningful analysis could be accomplished in the limited time available. Clearly, the topic of attrition merits extensive additional investigation.

General Observations

Overall, the analysis would indicate that the Alaskan theater airlift system would have a reasonable chance to execute its wartime mission under average conditions. Although more validation work is required before the closure times yielded by the model can be used for predictive purposes, it would appear that the general range of times is such that attainment of theater objectives would be feasible. For the flow analyzed, a simultaneous two-battalion move could theoretically be completed by theater airlift forces in 3.5 to 6 days from initial forward airhead airdrops to final movement of cargo and personnel to the forward airhead. With planned augmentation, this time would be decreased, but only to a minimum of about three days because of forward airhead limitations. Of course, with adverse weather or other constraints, these times would undoubtedly be greater, but the analysis would seem to indicate that the flow could still be closed within seven to eight days, barring extreme conditions. With threat, the question of flow completion becomes problematic, since it would appear that the Alaskan airlift force simply cannot afford attrition.

Summary

This chapter has discussed the use of the model for preliminary analysis of the Alaskan theater. Specifically, it showed how the model can be used for both screening designs (to quickly detect important factors) and for in-depth analysis (to explore the nature of effects of a smaller number of significant factors). The value of model output to operational planners was demonstrated and several conclusions were drawn about the performance of the Alaskan theater airlift system. The next chapter will summarize the results of this thesis and will offer conclusions about the viability of the model and recommendations concerning its future applications.

VII. Conclusions and Recommendations

Summary

This study has examined the performance of the Alaskan theater airlift system in a representative wartime operating mode through the use of a simulation model. First, the Alaskan theater was described and the major difficulties which it presented to planned wartime operations were discussed; also, several likely wartime scenarios for the theater were outlined. Next, the Alaskan airlift system was examined and its basic functions and components identified; certain assumptions were made about how these would be included in the proposed model. A simulation model was then developed which incorporated the major elements of the system and its likely wartime operation. This model was carefully checked for proper operation and validated against available data from the existing airlift system. The model was then run under conditions similar to the "worst-case" scenario earlier outlined. A screening experiment was executed to determine which factors significantly affected system performance. The two most important factors, number of aircraft and number of aircrews, were then analyzed to determine the nature of their effects. The results of these analyses allow several conclusions to be drawn about system performance and about the model itself.

Conclusions

Model Viability. Based on the results of this thesis, it would appear that a simulation model tailored to the particular combination of conditions in Alaska can effectively be used to analyze Alaskan theater airlift system performance. Although the model does not include all of the detail of the system, general

estimates of system capability and performance can still be obtained. In particular, the model can be used to examine the nature of the effects of various factors on system operation under a wide range of scenarios. The output of such studies, while perhaps not accurate enough to be used as a purely predictive tool, can be extremely useful in force planning and capability evaluation. Given the nature of the results obtained, the model may also have a useful predictive potential, although such use would require more validation.

Significant Factors. Within the scope of system components modeled, number of aircraft and number of aircrews most directly affect system performance under "average" operating conditions. To a lesser extent, length of crew day, season, and weather can exert significant influences on system operation. Factors such as physical limitations at airfields and materials handling equipment were found to have relatively small effects on the system under the scenarios considered.

Aircraft/Aircrew Interaction. The numbers of available aircraft and aircrews have a very complex but remarkably well-defined effect on system capability. For a particular scenario and a given number of aircraft, system performance can be improved by addition of more aircrews, but only up to a certain point. Beyond this point, which can be easily identified by graphical analysis, introduction of more crews into the system will have no effect. This point represents the optimum crew-to-aircraft ratio for a given scenario. (For a given number of crews, system performance can similarly be improved by additional aircraft, but only up to the point of optimality.) For the scenarios examined, the optimum crew ratio was approximately 1.6 crews per aircraft, not including "overhead" crews required

for ground duties. Since the single active-duty Alaskan airlift unit is currently manned at only a 1.5 ratio, it would appear that more aircrews would improve the wartime airlift capability.

Another important aspect of the aircraft/aircrew effect is that improvements in system capability become increasingly more costly in terms of additional aircraft and aircrews required as the theoretical minimum time for completing a given scenario is approached. Indeed, the tradeoff appears to follow an exponential pattern for the scenarios examined, and it is probable that the pattern is similar (although perhaps shifted in magnitude) for the conditions most likely to obtain in the theater. From the results obtained, however, it would appear that the existing airlift force (with planned augmentation and perhaps with some additional crews) should be capable of satisfactorily handling the most likely wartime requirements.

Recommendations

This model represents a first step in evaluating Alaskan theater airlift capability. It is additionally a different (if not completely new) approach to the problem of theater logistics analysis in general and to the specific area of theater airlift modeling. The model incorporates several new or expanded features such as risk, variable weather, aborts, airdrops, and specific mission input, as well as the important aspect of ease of control by the user. Since the model and the investigations conducted represent only a first step, further research into the Alaskan or other theater airlift systems using this model could profitably examine a number of areas.

Attrition. Very limited examination was made of attrition, and no meaningful analysis could be made of the results obtained.

If airlift aircraft must operate into a high threat area, attrition would be a very serious problem. Investigations in this area should examine the effects of both replacement and non-replacement of aircraft and crews, since it is reasonable to assume that replacement of already-critical aircraft in wartime might be very limited.

Additional Bases. For the Alaskan system, it might be worthwhile to examine system performance under a "split" move. Such a scenario would involve operation of two separate and possibly simultaneous flows to the forward area, and would bring variable weather and distance into more prominence. This would require adding another fighter/staging base, another forward airhead, and perhaps one or more additional CCI sites. The model can be modified to include additional bases, although this would require some rewriting of the FORTRAN code and addition of the appropriate base networks. Use of additional bases should be carefully weighed against added model complexity, however, since model complexity grows exponentially as the number of bases is increased.

Maintenance and Aerial Port. Home base maintenance and aerial port functions could be modeled in much more detail, although to do so would greatly complicate the model. One advantage to such modeling, however, would be to allow examination of the effect of decreasing spare parts levels on mission flow. This could become a form of attrition as aircraft were forced to be grounded for lack of engines, propellers, and other key components. A possible approach might be to track the stock levels of several critical assemblies; indeed, the model already includes provisions for tracking engines and propellers (although this capability was not used in the analysis because of lack of

accurate replacement rate data). The abort triggering structure (which largely reflects aircraft reliability) could also be modeled in more detail; this would allow the testing of the system's sensitivity to differing abort rates.

Interactive Operation. One of the major drawbacks of theater-oriented models is that theater systems normally operate on a day-by-day basis, with reallocation of resources and determination of airlift requirements being accomplished each day. Since currently available simulation languages such as SLAM are strictly batch-oriented, the modeler must try to anticipate all situations into which the model may be driven during relatively long periods of operation. A possible way to overcome this drawback might be to make multiple parallel 24-hour runs and then to average the results. Parameters and requirements for the next day could then be entered, taking into account the previous day's performance, and the model run for another 24 hours. Although this approach would move the theater modeling process closer to a war-gaming concept, it would open up a broad new area of application for modeling. (Use of airlift models for actual war gaming might even be feasible.) In any case, a day-by-day approach would give the modeler far more control over model performance and would allow execution of very complicated and highly realistic scenarios. The 24-hour approach could be used with this model since it is designed to be easily controlled; however, it would require a succession of batch jobs which might take a great deal of time and would not be as economical as a truly interactive model.

Comment

As mentioned at the beginning of this study, the Alaskan theater is unlikely ever to become a major trouble spot. However, this does not preclude the use of Alaska as a testing ground for operations in other, more volatile areas. This is, in fact, what is being done on at least a limited scale by the Military Airlift Command and the U.S. Army. Since Alaska provides an in-place theater airlift capability and a wide variety of operating environments, it can simulate many northern latitude operating locations. Additionally, the great distances, sparse population, and lack of surface transportation give Alaska many similarities with other areas of interest. In particular, Alaska is typical of many areas where airlift would be the primary means of transportation, and in which analysis of the logistics system as a whole tends to center upon the airlift network. Accordingly, examination of airlift in Alaska can provide insight into many non-Alaskan areas which may not be amenable to examination using other methods or models. This model, then, is not simply a model for use in Alaska; rather, it represents an alternate approach to an important aspect of the overall theater logistics problem.

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Appendix A
Network Diagrams and SLAM Network

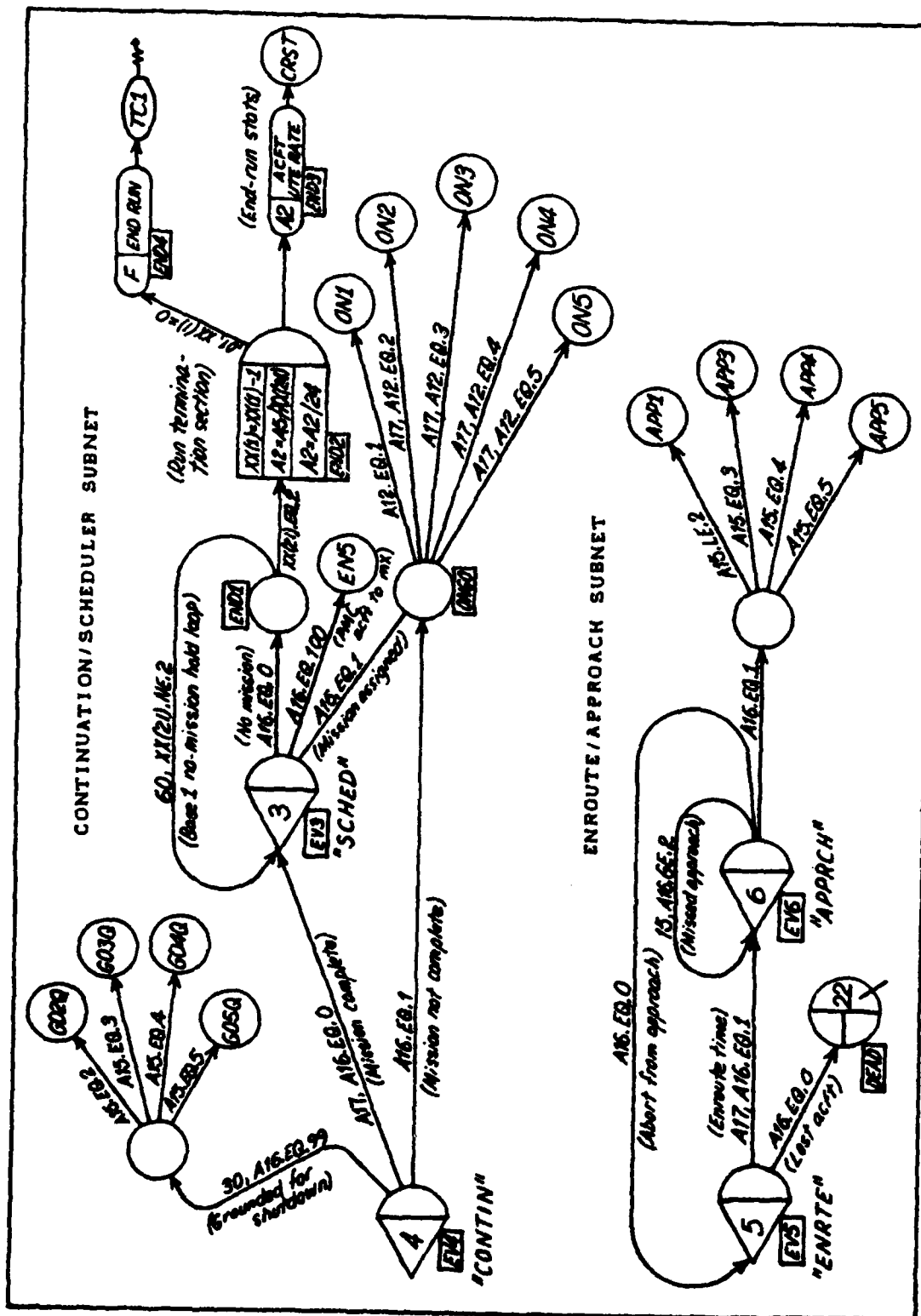
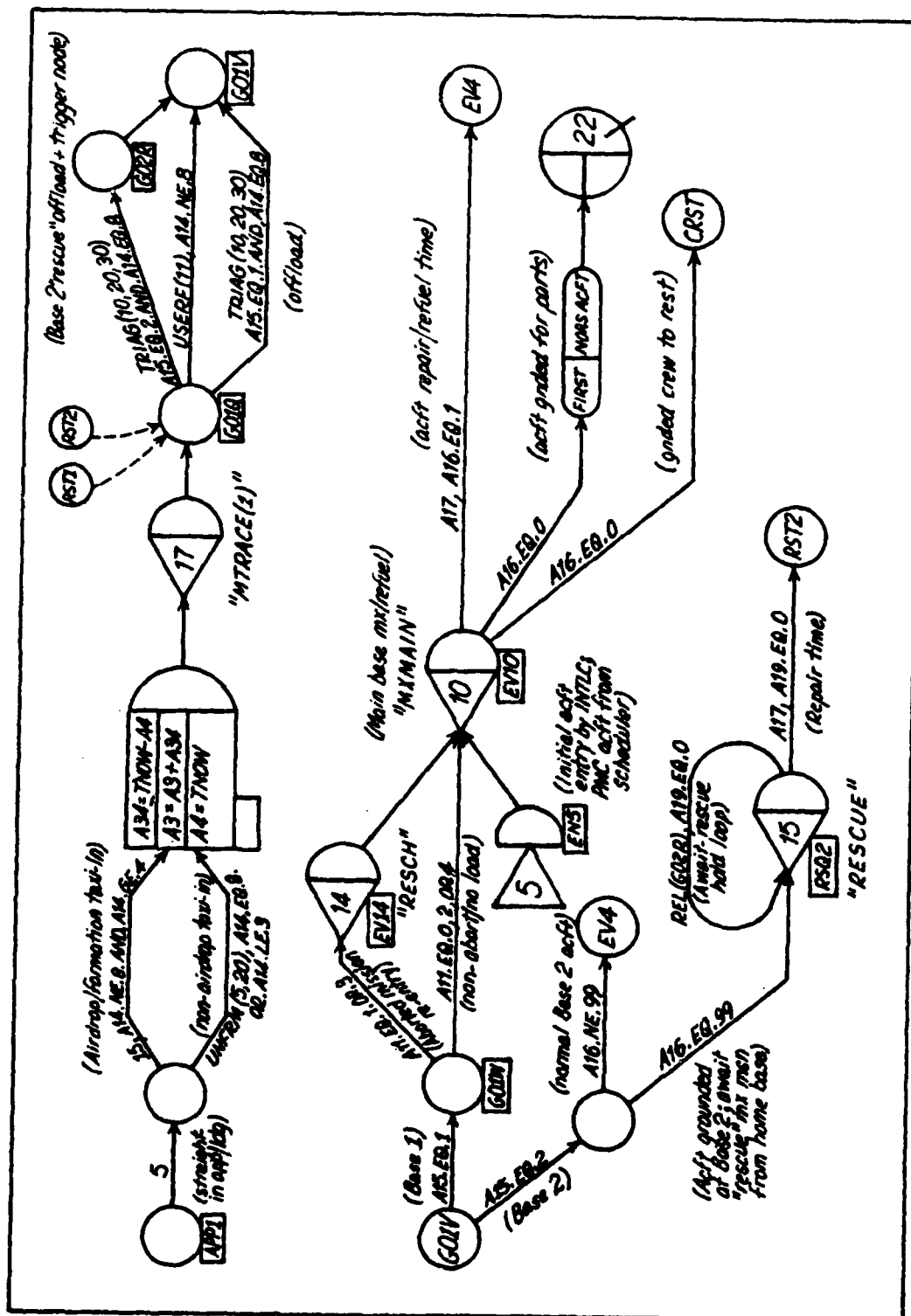


Figure 11: Continuation and Enroute Subnets



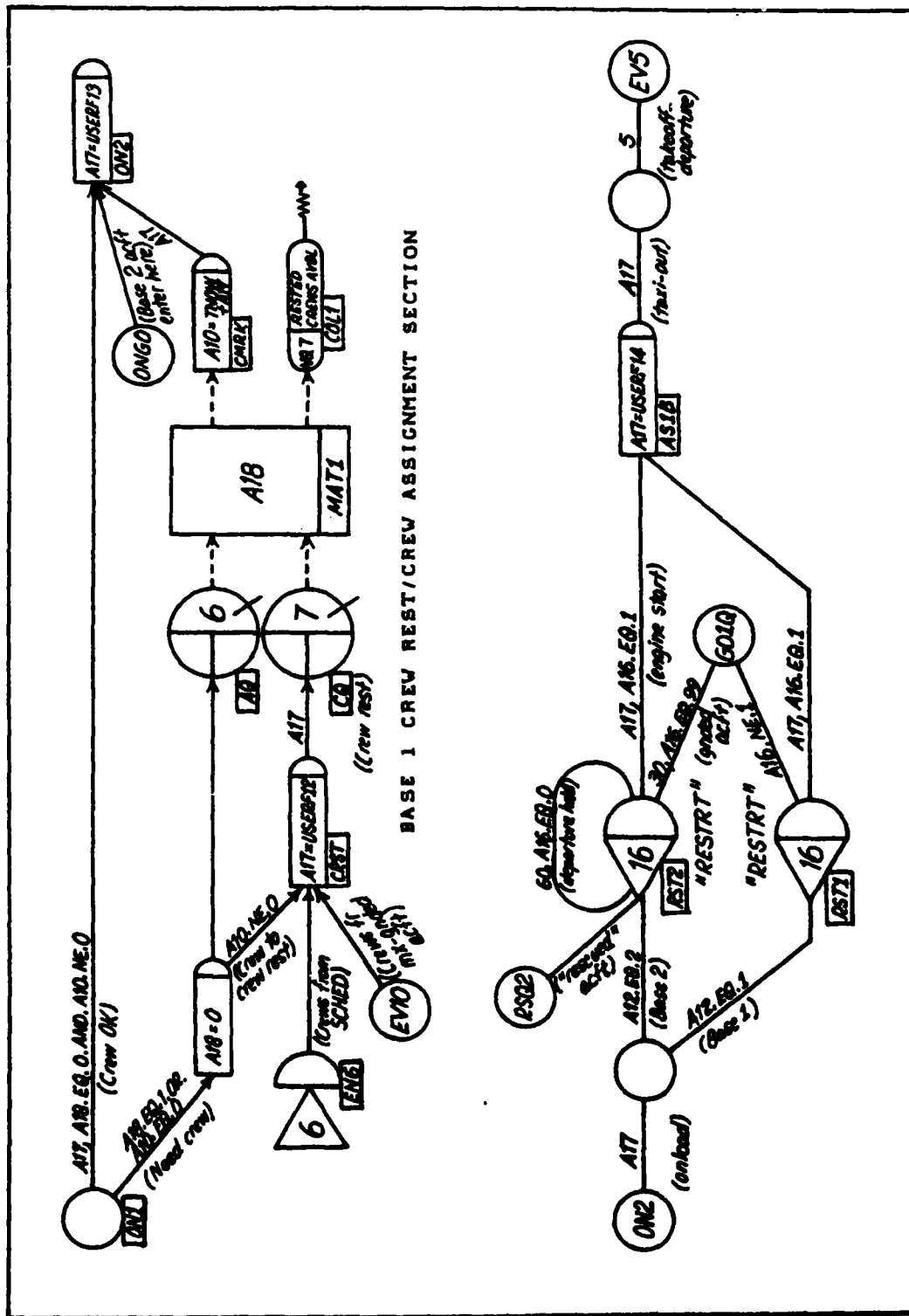


Figure 13: Base 1/2 Departure Subnet

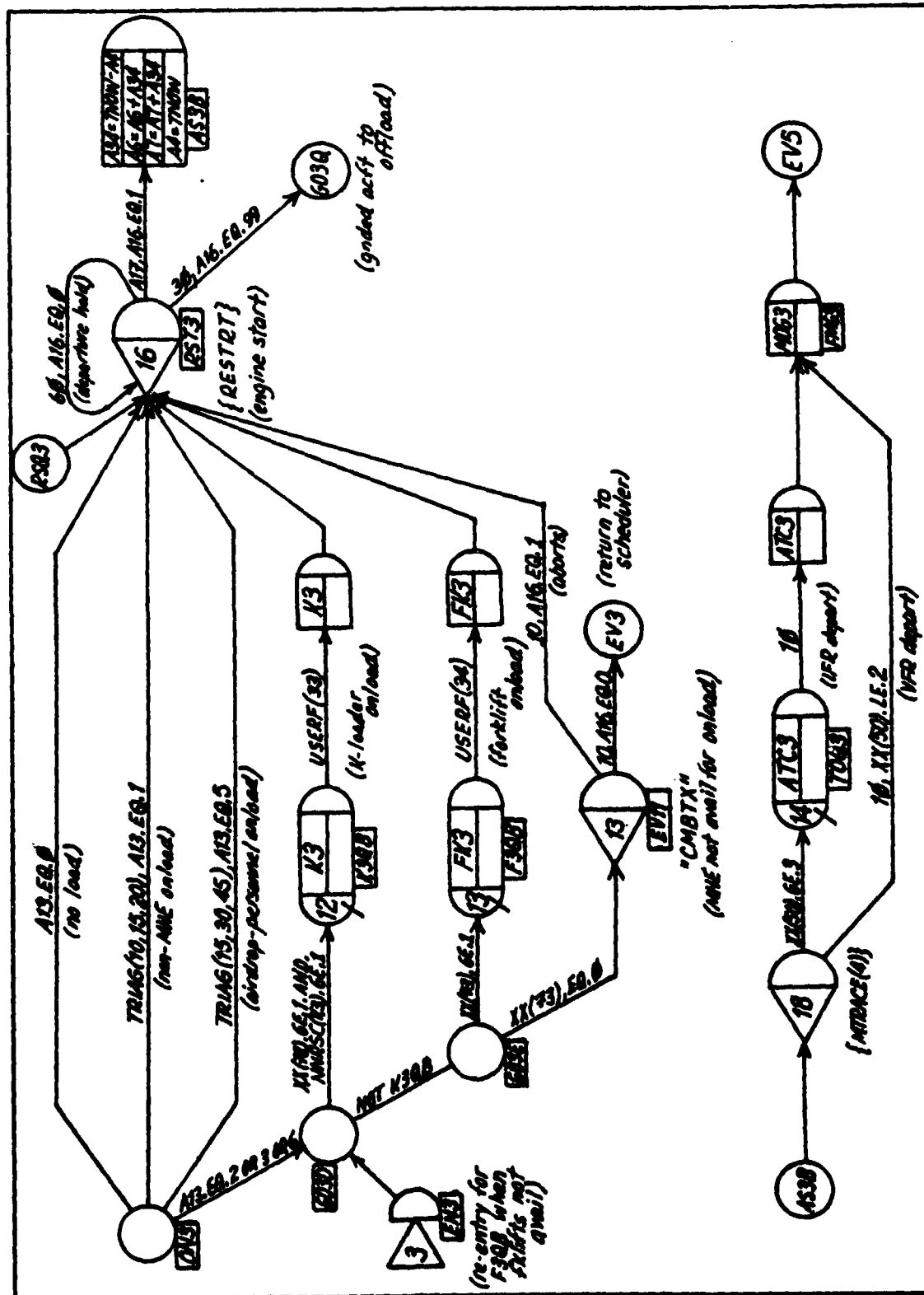


Figure 15: Base 3 Departure Subnet

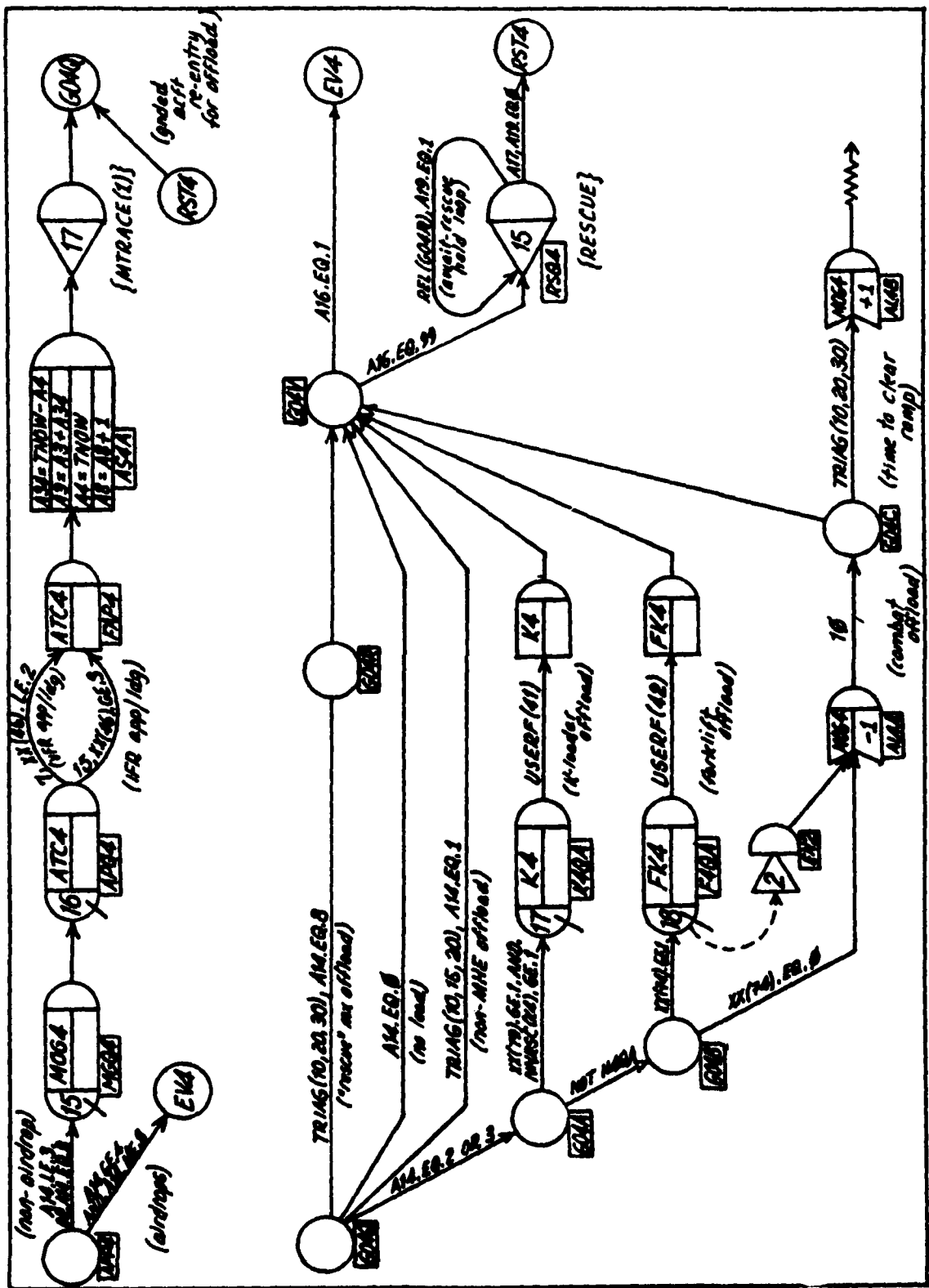
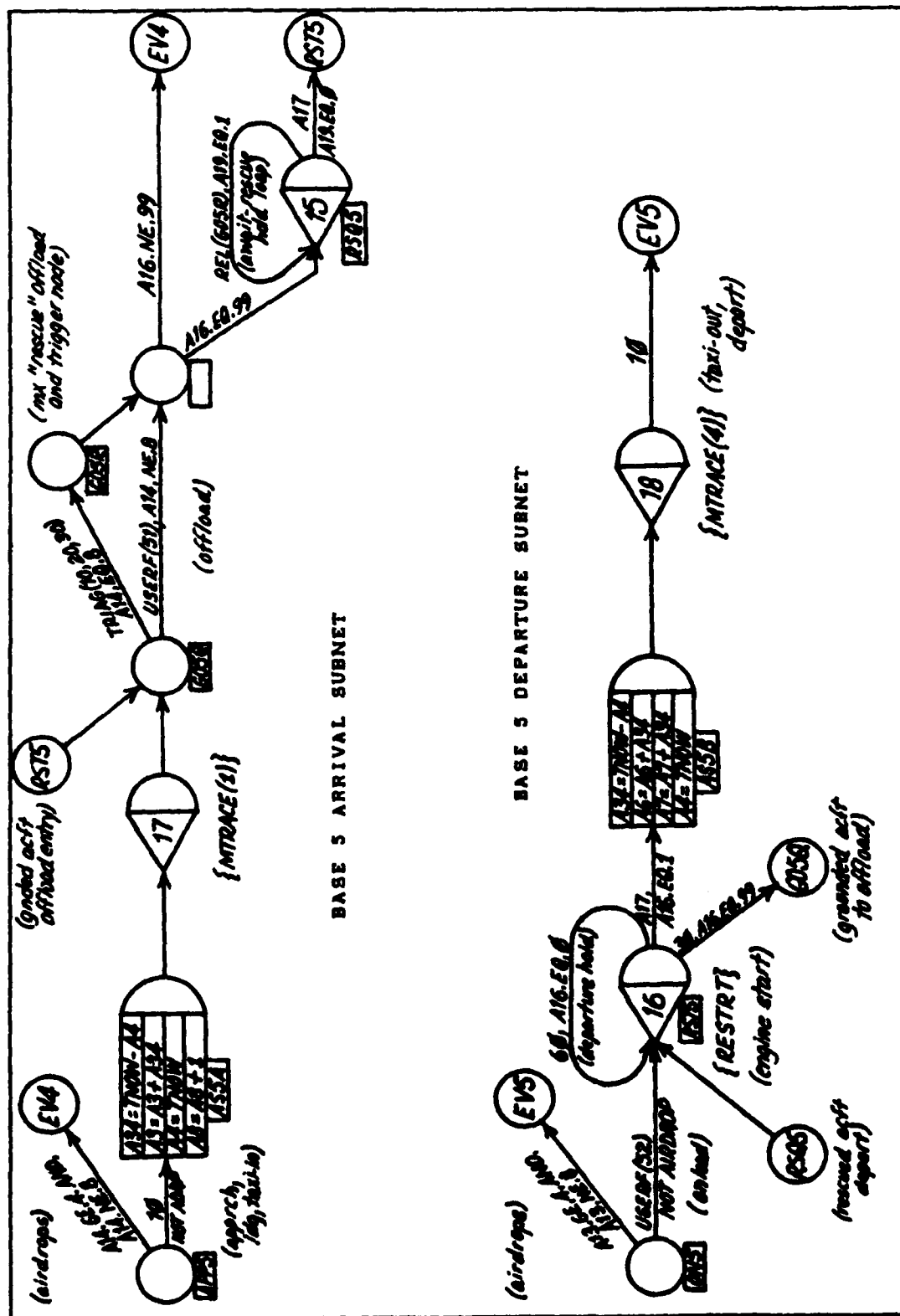


Figure 10: Base 4 Arrival Subnet



```

DSB,CM177000,10600,T1200. T820043 BOWERS 4339
ATTACH,PROCFIL,ID=A810171,SN=ASDAD.
BEGIN,NOSFILE.
GET,MAIN,ID=DB.
GET,MSTACK,ID=DB.
ATTACH,PROCFIL,SLAMPROC,ID=AFIT.
BEGIN,SLAM,,M=MAIN,PL=20000.
*EOR
GEN,BOWERS,THEATER AIRLIFT NET,2,10,82,33; ***** TOTAL OF 33 RUNS
LIMITS,22,40,300; ***** MAX OF 22 FILES, 40 ATRIBS, 300 ENTITIES
STAT,1,FUEL USED; ***** COLLECT STATISTICS BASED ON OBSERVATION
STAT,2,MSN FLY TIME; (STAT 10 NOT USED)
STAT,3,CREW DAY LENGTH;
STAT,4,GNDTIM 1;
STAT,5,GNDTIM 2;
STAT,6,GNDTIM 3;
STAT,7,GNDTIM 4;
STAT,8,GNDTIM 5;
STAT,9,SORTIE LENGTH;
STAT,11,MSN SCHD DLAY;
STAT,12,MSN COMP DLAY;
STAT,13,CLOSURE TIME;
TIMST,XX(1),ACFT; ***** COLLECT TIME-AVERAGED STATISTICS
TIMST,XX(2),CREWS; ON KEY GLOBAL VARIABLES
TIMST,XX(3),ENGINES;
TIMST,XX(4),PROPS;
TIMST,XX(5),TIRES;
TIMST,XX(21),ENDSWCH;
TIMST,XX(22),MSNS ENT;
TIMST,XX(23),MSNS CMP;
TIMST,XX(24),CLOSETIM;
TIMST,XX(63),MOG3;
TIMST,XX(64),MOG4;
TIMST,XX(73),FK3;
TIMST,XX(74),FK4;
NETWORK; ***** BEGIN NETWORK LISTING
RESOURCE/MOG3,8; DEFINE RESOURCES
RESOURCE/ATC3,14,9; (LEVELS ARE SET
RESOURCE/K3,12,10; DURING EXECUTION
RESOURCE/FK3,13,11; BY GLOBAL VRBLs
RESOURCE/MOG4,15; AND SUBROUTINE
RESOURCE/ATC4,21,16; INTLC)
RESOURCE/K4,10,17;
RESOURCE/FK4,20,18;
; CONTINUATION-SCHEDULER SUBNET
EV4 EVENT,4; CONTINUATION CHECK
ACT/1,ATRI(17),ATRI(16).EQ.0,EV3; ACFT FREE, GO TO SCHED
ACT/4,,ATRI(16).EQ.1,ONGO; MORE LEGS, GO TO DEPT
ACT,30,ATRI(16).EQ.00; ACFT GNDSD
GOON,1;
ACT,,ATRI(15).LE.2,GO1Q; GNDSD ACFT TO
ACT,,ATRI(15).EQ.3,GO3Q; APPROPRIATE BASE
ACT,,ATRI(15).EQ.4,GO4Q; OFFLOAD SUBNETS
ACT,,ATRI(15).EQ.5,GO5Q;

```

EV3	EVENT,3,1; ACT,,ATRIB(16).EQ.0,END1; ACT/2,,ATRIB(16).EQ.1,ONGO; ACT,,ATRIB(16).EQ.100,EN5; ;	SCHEDULER NO MSN, WAIT 1 HR MSN ASCD, GO TO DEPT NO PMC MSNS AVAIL -- PMC ACFT TO MMMAIN BRANCH TO DEPT SUBNETS
ONGO	GOON; ACT/5,,ATRIB(12).EQ.1,ON1; ACT/6,ATRIB(17),ATRIB(12).EQ.2,ON2; ACT/7,ATRIB(17),ATRIB(12).EQ.3,ON3; ACT/8,ATRIB(17),ATRIB(12).EQ.4,ON4; ACT/9,ATRIB(17),ATRIB(12).EQ.5,ON5;	
END1	GOON,1; ACT/3,00,,XX(21).NE.2,EV3; ACT/97;	NO MSN -- 1-HR HOLD NO MSN -- END OF RUN
END2	ASSIGN,XX(1)=XX(1)-1; ASSIGN,ATRIB(2)=ATRIB(5)/XX(24); ASSIGN,ATRIB(2)=ATRIB(2)*24; ACT,,XX(1).EQ.0,END3; ACT;	DECR ACFT IN SYS SET UP UTE RATE BASED ON CLOSURE TIME LAST ACFT, TERMINATE ACFT, CREW TO STAT COL
END4	COLCT,ATRIB(2),ACFT UTE RATE; ACT,,CRST;	
END3	COLCT,FIRST,END OF RUN; ACT,1; TERMINATE,1;	
	; DEPARTURE SUBNETS ; BASE 1 DEPARTURE SUBNET	
ON1	GOON,1; ACT/60,ATRIB(17),ATRIB(18).EQ.0.AND.ATRIB(10).GE.1,ON2; ACT/61; ASSIGN,ATRIB(18)=0; ACT/62,,,AQ; ACT,.01,ATRIB(10).GE.1,CRST;	NEED NEW CREW ACFT TO NEED-CREW QUEUE
EN6	ENTER,6;	CREWS FROM SCHED
CRST	ASSIGN,ATRIB(17)=USERF(12); ACT/98,ATRIB(17);	COMPUTE CREW REST CREW REST
CQ	QUEUE(7),,,,MAT1;	RESTED-CREW QUEUE
AQ	QUEUE(6),,,,MAT1;	ACFT NEED-CREW QUEUE
MAT1	MATCH,18,AQ/CMRK,CQ/COL1;	MATCH ACFT AND CREWS
COL1	COLCT,MNQ(7),RSTD CREWS AVBL; ACT/65; TERMINATE;	
CMRK	ASSIGN,ATRIB(10)=TNOW+ATRIB(17); ASSIGN,ATRIB(33)=0; ACT,ATRIB(17);	MARK NEW CREW START TIME
ON2	ASSIGN,ATRIB(17)=USERF(13); ACT/66,ATRIB(17); GOON,1; ACT,,ATRIB(12).EQ.1,RST1; ACT;	BASE 2 ACFT REENTER HERE ONLOAD IF BASE 1, GO TO RSTRT
RST2	EVENT,16,1; ACT,60,,ATRIB(16).EQ.0,RST2; ACT,30,,ATRIB(16).EQ.99,GO10; ACT,ATRIB(17),,AS1B;	RSTRT: ENGINE START 2 ABORT, HOLD FOR WX BREAK - NEED RESCUE PROCEED
RST1	EVENT,16,1;	RETSRT BASE 1

ACT,,ATRIB(16).NE.1,GO1Q;	BREAK --MSN ABORT
ACT,ATRIB(17);	PROCEED
AS18 ASSIGN,ATRIB(17)=USERF(14);	
TR12 EVENT,18,1;	MISSION TRACE - DEPART
ACT,ATRIB(17);	TAXI-OUT
GOON;	
ACT,5,,,EV5;	GO TO ENROUTE
; BASE 3 DEPARTURE SUBNET	
ON3 GOON,1;	
ACT,,ATRIB(13).EQ.0,RST3;	NO LOAD
ACT,TRIAG(10.,15.,20.),ATRIB(13).EQ.1,RST3;	NON-CARGO LOAD
ACT,TRIAG(15.,30.,45.),ATRIB(13).EQ.5,RST3;	PERS AIRDROP ONLOAD
ACT/81,,,GO3D;	LOADS NEEDING MHE
EN3 ENTER,3;	ENTER MSNB FROM CMET3A
ACT/86;	GO TO K3 AVAIL CHECK
GO3D GOON,1;	
ACT/82,,XX(78).GE.1.AND.NNRSC(K3).GE.1,K3QB;	USE K3 ONLY
	IF NO WAITING
ACT/83;	GO TO FK3 AVAIL CHECK
GO3E GOON,1;	
ACT/84,,XX(73).GE.1,F3QB;	IF FK3 IN SVC, ENTER AWAIT
ACT/85;	NO FK3 IN SVC, RESCH3
EV11 EVENT,13,1;	CMETX: IF NO FK3 AVAIL,
ACT,10,ATRIB(16).EQ.0,EV3;	REENT MSN, ACFT TO SCHD
ACT,10,ATRIB(16).EQ.1,RST3;	ABORT ACFT GO HOME EMPTY
K3QB AWAIT(12),K3;	AWAIT K3 FOR ONLOAD
ACT,USERF(33);	ONLOAD
FREE,K3;	
ACT,,,RST3;	
F3QB AWAIT(13),FK3;	AWAIT FK3 FOR ONLOAD
ACT,USERF(34);	ONLOAD
FREE,FK3;	
RST3 EVENT,18,1;	RESTART: ENG STRT 3
ACT,60.,ATRIB(16).EQ.0,RST3;	ABORT, HOLD FOR WX
ACT,30.,ATRIB(16).EQ.99,GO3Q;	BREAK - NEED RESCUE
ACT,ATRIB(17);	
AS3B ASSIGN,ATRIB(34)=TNOW-ATRIB(4);	GNDTIM
ASSIGN,ATRIB(6)=ATRIB(6)+ATRIB(34);	UPDATE ENG TFAIL
ASSIGN,ATRIB(7)=ATRIB(7)+ATRIB(34);	UPDATE PROP TFAIL
ASSIGN,ATRIB(4)=TNOW,1;	RESET START/STOP TIME
TR32 EVENT,18,1;	MISSION TRACE - DEPART
ACT/87,10.,XX(50).LE.2,FMG3;	VFR DEPARTURE
ACT,,,TOQ3;	
TOQ3 AWAIT(14),ATC3;	AWAIT TAKEOFF CLNC
ACT,15;	IFR DEPARTURE
FREE,ATC3;	OUT OF LOCAL AREA
FMG3 FREE,MOG3;	
ACT/89,,,EV5;	GO TO ENROUTE
; BASE 4 DEPARTURE SUBNET	
ON4 GOON,1;	
ACT/90,,ATRIB(13).GE.4,EV5;	AIRDROPS GO TO ENROUTE
ACT,,ATRIB(13).EQ.0,RST4;	NO LOAD
ACT,TRIAG(5.,10.,15.),ATRIB(13).EQ.1,RST4;	NON-CARGO LOAD
ACT/91,,,GO4D;	LOADS NEEDING MHE

EN4	ENTER,4; ACT/90;	ENTER MSNS FROM CMBT4A GO TO K4 AVAIL CHECK
GO4D	GOON,1; ACT/92,,XX(79).GE.1.AND.NNRSC(K4).GE.1,K4QB; USE K4 ONLY IF NO WAITING GO TO FK3 AVAIL CHECK	
GO4E	GOON,1; ACT/93; ACT/94,,XX(74).GE.1,F4QB; ACT/95;	IF FK4 IN SVC, ENTER QUEUE NO FK4 IN SVC, RESCH4 CMBTX: IF NO FK4 AVAIL, REENT MSN, ACFT TO SCHD ABORT ACFT GO HOME EMPTY AWAIT K4 FOR ONLOAD ONLOAD
EV12	EVENT,13,1; ACT,10,ATRI(16).EQ.0,EV3; ACT,10,ATRI(16).EQ.1,RST4;	
K4QB	AWAIT(19),K4; ACT,USERF(43); FREE,K4; ACT,,,RST4;	
F4QB	AWAIT(20),FK4; ACT,USERF(43); FREE,FK4;	AWAIT FK4 FOR ONLOAD ONLOAD
RST4	EVENT,16,1; ACT,60.,ATRI(16).EQ.0,RST4; ACT,30.,ATRI(16).EQ.99,GO4Q; ACT,ATRI(17);	RESTART: ENG STRT 4 ABORT - HOLD FOR WX BREAK - NEED RESCUE PROCEED
AS4B	ASSIGN,ATRI(34)=TNOW-ATRI(4); ASSIGN,ATRI(6)=ATRI(6)+ATRI(34); ASSIGN,ATRI(7)=ATRI(7)+ATRI(34); ASSIGN,ATRI(4)=TNOW,1;	GNDTIM UPDATE ENG TFAIL UPDATE PROP TFAIL
TR42	EVENT,18,1;	MISSION TRACE - DEPART
TOQ4	AWAIT(21),ATC4; ACT,15; FREE,ATC4; FREE,MOG4; ACT,,,EV5;	AWAIT TAKEOFF CLNC IFR DEPARTURE OUT OF LOCAL AREA GO TO ENROUTE
; BASE 5 DEPARTURE SUBNET		
ONS	GOON,1; ACT/53,,ATRI(13).GE.4.AND.ATRI(13).NE.6,EV5; AIRDROPS ACT/54,USERF(52);	ONLOAD
RST5	EVENT,16,1; ACT,60.,ATRI(16).EQ.0,RST5; ACT,30.,ATRI(16).EQ.99,GO5Q; ACT,ATRI(17);	RESTART: ENG STRT 5 ABORT - HOLD FOR WX BREAK - NEED RESCUE
AS5B	ASSIGN,ATRI(34)=TNOW-ATRI(4); ASSIGN,ATRI(6)=ATRI(6)+ATRI(34); ASSIGN,ATRI(7)=ATRI(7)+ATRI(34); ASSIGN,ATRI(4)=TNOW;	GNDTIM UPDATE ENG TFAIL UPDATE PROP TFAIL RESET START/STOP FLAG
TR52	EVENT,18,1; ACT,10,,,EV5;	MISSION TRACE - DEPART GO TO ENROUTE
; ENROUTE-APPROACH SUBNET		
EV5	EVENT,5,1; ACT/20,,ATRI(16).EQ.0,COL2; ACT/20,ATRI(17),EV6;	ENRTE: SETS ENRTE TIMES, CHECKS WX AND THREAT ACFT LOST TO THREAT ENRTE TIME, GO TO APPROCH
COL2	COLCT,FIRST,LOST ACFT;	

ACT,,DEAD;	ACFT TO DEAD FILE
EV6 EVENT,8,1;	APPRCH:
ACT/27,15,,ATRI(16).GE.2,EV6;	MISSED APPROACH, TRY AGAIN
ACT/28,,ATRI(16).EQ.0,EV5;	CANT GET IN, GO TO ENRTE
ACT/20;	SUCCESSFUL APPRCH
APGO GOON,1;	GO TO ARRIVAL SUBNET
ACT/21,,ATRI(15).LE.2,APP1;	
ACT/23,,ATRI(15).EQ.3,APP3;	
ACT/24,,ATRI(15).EQ.4,APP4;	
ACT/25,,APP5;	
;	
; BASE ARRIVAL SUBNETS	
; BASE 1 AND 2	
APP1 GOON;	
ACT/10,5,;	STRAIGHT-IN APPROACH
GOON;	
ACT,15,,ATRI(14).GE.4,AS1A;	AIRDROP TAXI-IN
ACT,TRIAG(5,,10,,20,,1),ATRI(14).LE.3,AS1A;	OTHER TAXI-IN
AS1A ASSIGN,ATRI(34)=TNOW-ATRI(4);	LECTIM
ASSIGN,ATRI(3)=ATRI(3)+ATRI(34);	UPDATE TFLY SINCE HOME
ASSIGN,ATRI(4)=TNOW;	RESET START/STOP FLAG
TR11 EVENT,17;	MISSION TRACE - ARRIVAL
GO1Q GOON,1;	REENTRY FOR BROKEN ACFT
ACT,TRIAG(10,,20,,30,,),ATRI(15).EQ.1.AND.ATRI(14).NE.8,GO1V;	OFFLOAD
ACT,USERF(11),ATRI(14).NE.8,GO1V;	RESCUE OFFLOAD
ACT,TRIAG(10,,20,,30,,);	REL NODE FOR RESCUED ACFT
GO2R GOON;	
GO1V GOON,1;	
ACT,,ATRI(15).EQ.1,GO1W;	BASE 1 TO RESCH
ACT/12;	BASE 2
GOON,1;	
ACT,,ATRI(16).NE.99,EV4;	REG BASE 2 TO CONTIN
ACT;	
RSQ2 EVENT,15,1;	CALL RESCUE MSN
ACT,REL(GO2R),ATRI(19).EQ.1,RSQ2;	ACFT AWAIT RESCUE
ACT,ATRI(17),ATRI(19).EQ.0,RST2;	FIXTIM FOR RESCUE
GO1W GOON,1;	
ACT/13,,ATRI(11).EQ.1.OR.ATRI(11).EQ.3,EV14;	GO TO RESCH
ACT/14,,EV10;	IF NOT ABORT, GO TO MXMAIN
EV14 EVENT,14;	RESCH1: RETURN ABORTED
;	MSNS TO MSN FILE
ACT,,EV10;	ACFT TO MXMAIN
EN5 ENTER,5;	INITIAL ACFT ENTRY
ACT/99;	
EV10 EVENT,10;	MXMAIN: MAIN BASE MX
ACT/15,ATRI(17),ATRI(16).EQ.1,EV4;	AFTER MX, GO TO CONTIN
ACT/16,,ATRI(16).EQ.0,CRST;	NORS ACFT CREW TO CREW REST
ACT,,ATRI(16).EQ.0;	NORS ACFT TO DEAD FILE
COLCT,FIRST,NORS ACFT;	
DEAD QUEUE(22);	FILE FOR OUT-OF-PLAY ACFT
; BASE 3 ARRIVAL SUBNET	
APP3 AWAIT(8),MOG3,1;	AWAIT ROOM ON GROUND
ACT/31,7,,XX(50).LE.2,AS3A;	VFR APPROACH/LDC
ACT/30;	WX IFR

APQ3	AWAIT(9),ATC3; ACT,12.; FREE,ATC3; ACT,5.;	AWAIT IFR CLNC IFR APPROACH/LDG CLEAR OF RUNWAY TAXI-IN
AS3A	ASSIGN,ATRI(34)=TNOW-ATRI(4); ASSIGN,ATRI(3)=ATRI(3)+ATRI(34); ASSIGN,ATRI(4)=TNOW,1;	LEGTIM UPDATE FLY TIM SINCE HOME
TR31	EVENT,17;	MISSION TRACE - ARRIVAL
GO3Q	GOON,1; ACT,TRIAG(10.,20.,30.),ATRI(14).EQ.8,GO3R; RESCUE OFFLOAD ACT,,ATRI(14).EQ.0.OR.ATRI(14).GE.4,GO3V; NO LOAD ACT,TRIAG(10.,15.,20.),ATRI(14).EQ.1,GO3V; NON-MHE ACT/32;	RE-ENTER FOR NEED-RESCUE MHE NEEDED
GO3A	GOON,1; ACT/33,,XX(78).GE.1.AND.NNRSC(K3).GE.1,K3QA; USE K3 ACT/34; GOON,1; ACT/35,,XX(73).GT.0,F3QA; ACT/36,,AL3A;	CHECK FK3 USE FK3 ALL FK3 DOWN
EN1	ENTER,1; ACT/37;	CMBT OFFLDS FROM F3QA ENTERED BY CMBT03
AL3A	ALTER,MOG3/-1; ACT/38,10.;	REDUCE GND SLOTS UNTIL ACTUAL OFFLD CMPLT AND CARGO DRAGGED CLEAR
GOON;	ACT,,GO3V; ACT,TRIAG(10.,30.,80.);	TIME TO CLEAR WHEN CLEAR, INCR MOG
TERMINATE;	ALTER,MOG3/1; TERMINATE;	
K3QA	AWAIT(10),K3; ACT,USERF(31); FREE,K3; ACT,,GO3V;	WAIT FOR K-LOADER OFFLOAD
F3QA	AWAIT(11),FK3; ACT,USERF(32); FREE,FK3; ACT,,GO3V;	GO TO CONTIN WAIT FOR FKLT OFFLOAD
GO3R	GOON;	GO TO CONTIN
GO3V	GOON,1; ACT,,ATRI(16).NE.80,EV4; ACT;	REL NODE FOR RESCUE
RSQ3	EVENT,15,1; ACT,REL(GO3R),ATRI(16).EQ.1,RSQ3; AWAIT RESCUE ACT,ATRI(17),ATRI(16).EQ.0,RST3; FIXTIM	CALL RESCUE 3
; BASE 4 ARRIVAL SUBNET		
APP4	GOON,1; ACT/40,,ATRI(14).GE.4.AND.ATRI(14).NE.8,EV4; AIRDROPS ACT/41;	TO CONTIN
MGO4	AWAIT(15),MOG4;	AWAIT ROOM ON GROUND
APQ4	AWAIT(16),ATC4,1; ACT/42,7.,XX(46).LE.1,FAP4; ACT/43,15.;	AWAIT IFR CLNC VFR APPROACH/LDG IFR APP/LDG
FAP4	FREE,ATC4;	CLEAR OF RUNWAY
AS4A	ASSIGN,ATRI(34)=TNOW-ATRI(4); ASSIGN,ATRI(3)=ATRI(3)+ATRI(34);	LEGTIM FLYTIME SINCE HOME

	ASSIGN, ATRIB(4)=TNOW, 1;	RESET START/STOP
	ASSIGN, ATRIB(8)=ATRIB(8)+1;	UPDATE MAX EFF LDGS
TR41	EVENT, 17;	MISSION TRACE - ARRIVAL
GO4Q	GOON, 1;	NEED-RESCUE REENTER
	ACT, TRIAG(10., 20., 30.), ATRIB(14).EQ.8, GO4R; RESCUE MSN	
	ACT, ATRIB(14).EQ.0 OR ATRIB(14).GE.4, GO4V; NO LOAD	
	ACT, TRIAG(10., 15., 20.), ATRIB(14).EQ.1, GO4V; NON-MHE	
	ACT/44;	MHE NEEDED
GO4A	GOON, 1;	
	ACT/45., XX(79).GE.1 AND NNRSC(K4).GE.1, K4QA; USE K4	
	ACT/46;	
	GOON, 1;	CHECK FK4
	ACT/47., XX(74).GT.0, F4QA;	USE FK4
	ACT/48., AL4A;	ALL FK4 DOWN
EN2	ENTER, 2;	CMST OFFLDS FROM F4QA
	ACT/49;	ENTERED BY CMST04
AL4A	ALTER, MOG4/-1;	REDUCE GND SLOTS UNTIL
	ACT, 10.;	ACTUAL OFFLD CMPLT
GOON;		AND CARGO DRAGGED
	ACT, GO4V;	CLEAR
	ACT, TRIAG(10., 30., 60.);	TIME TO CLEAR
	ALTER, MOG4/1;	WHEN CLEAR, INCR MOG
	TERMINATE;	
K4QA	AWAIT(17), K4;	WAIT FOR K-LOADER
	ACT, USERF(41);	OFFLOAD
	FREE, K4;	
	ACT, GO4V;	GO TO CONTIN
F4QA	AWAIT(18), FK4;	WAIT FOR FK4FT
	ACT, USERF(42);	OFFLOAD
	FREE, FK4;	
	ACT, GO4V;	GO TO CONTIN
GO4R	GOON;	RESCUE TRIGGER NODE
GO4V	GOON, 1;	
	ACT, ATRIB(16).NE.99, EV4;	REG MSN TO CONTIN
	ACT;	
RSQ4	EVENT, 15, 1;	CALL RESCUE 4
	ACT, REL(GO4R), ATRIB(19).EQ.1, RSQ4;	AWAIT RESCUE
	ACT, ATRIB(17), RST4;	FIXTIM
	; BASE 3 ARRIVAL SUBNET	
APPS	GOON, 1;	
	ACT, ATRIB(14).GE.4 AND ATRIB(14).NE.8, EV4; AIRDROP	
	ACT, 10.;	APPROACH/LDG/TAXI
AS3A	ASSIGN, ATRIB(34)=TNOW-ATRIB(4);	LECTIM
	ASSIGN, ATRIB(3)=ATRIB(3)+ATRIB(34);	FLYTIN SINCE HOME
	ASSIGN, ATRIB(4)=TNOW;	RESET START/STOP
	ASSIGN, ATRIB(8)=ATRIB(8)+1;	UPDATE MAX EFF LDC
TR51	EVENT, 17;	MISSION TRACE - ARRIVAL
GO5Q	GOON, 1;	
	ACT, USERF(51), ATRIB(14).NE.8, GO5V; OFFLOAD	
	ACT, TRIAG(10., 20., 30.), ATRIB(14).EQ.8; RESCUE OFFLOAD	
GO5R	GOON;	RESCUE TRIGGER NODE
GO5V	GOON, 1;	
	ACT, ATRIB(16).NE.99, EV4;	REG MSN TO CONTIN
	ACT;	

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RSQ5  EVENT,15,1;                                CALL RESCUE 5
      ACT,REL(GOSR),ATTRIB(19).EQ.1,RSQ5;  AWAIT RESCUE
      ACT,ATTRIB(17),,RST5;                FIXTIM
ENDNETWORK;
INITIALIZE,0.,20160.; ***** DEFAULT STOP TIME IS T=20160
***** DEFAULT SETTINGS FOR GLOBAL VARIABLES
INTLC, XX(1)=10, XX(2)=15, XX(3)=50, XX(4)=50, XX(5)=0;
INTLC, XX(10)=960, XX(11)=3, XX(12)=5, XX(13)=10;
INTLC, XX(20)=0, XX(21)=0, XX(22)=0, XX(23)=0, XX(24)=0;
INTLC, XX(26)=0, XX(31)=1, XX(32)=1, XX(34)=0, XX(35)=0;
INTLC, XX(36)=1, XX(37)=0;
INTLC, XX(41)=2, XX(42)=2, XX(43)=2, XX(44)=2, XX(45)=2;
INTLC, XX(46)=2, XX(47)=2, XX(48)=2, XX(49)=2, XX(50)=2;
INTLC, XX(63)=6, XX(64)=2, XX(68)=2, XX(69)=1;
INTLC, XX(73)=4, XX(74)=2, XX(78)=1, XX(79)=0;
INTLC, XX(81)=2, XX(82)=2, XX(83)=2, XX(84)=1, XX(85)=1;
INTLC, XX(88)=6, XX(89)=3, XX(90)=2;
INTLC, XX(97)=0, XX(98)=0, XX(99)=0; XX(100)=0;
PRIORITY,1,LVF(5); ***** SPECIFY MISSION FILE PRIORITY
PRIORITY,2,LVF(5);                                RANKING SYSTEM
PRIORITY,3,LVF(5);
PRIORITY,4,LVF(5);
PRIORITY,5,LVF(5);
; ***** DEFAULT RUN COMPLETED
SIMULATE; BEGIN DATA RUN 1 ***** BEGIN 32-RUN SCREENING DESIGN
INTLC, XX(1)=10, XX(2)=15, XX(10)=720, XX(31)=3, XX(34)=2;
INTLC, XX(63)=4, XX(64)=2, XX(68)=1, XX(69)=1, XX(73)=1, XX(74)=1;
INTLC, XX(78)=2, XX(79)=1, XX(83)=2, XX(84)=1;
SIMULATE; BEGIN 2
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=3, XX(68)=2, XX(69)=2, XX(73)=4, XX(74)=2;
INTLC, XX(78)=0, XX(79)=0, XX(83)=1, XX(84)=0;
SIMULATE; BEGIN 3
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(69)=1, XX(73)=1, XX(74)=1;
INTLC, XX(84)=1;
SIMULATE; BEGIN 4
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=2, XX(68)=1, XX(69)=2, XX(73)=4, XX(74)=2;
INTLC, XX(78)=2, XX(79)=1, XX(83)=2, XX(84)=0;
SIMULATE; BEGIN 5
INTLC, XX(1)=10, XX(2)=15, XX(10)=960;
INTLC, XX(63)=10, XX(74)=1;
INTLC, XX(78)=0, XX(79)=0;
SIMULATE; BEGIN 6
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=3, XX(68)=2, XX(69)=1, XX(73)=1, XX(74)=2;
INTLC, XX(78)=2, XX(79)=1, XX(83)=1, XX(84)=1;
SIMULATE; BEGIN 7
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(69)=2, XX(73)=4, XX(74)=1;
INTLC, XX(84)=0;
SIMULATE; BEGIN 8
INTLC, XX(1)=40;

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INTLC, XX(63)=10, XX(64)=2, XX(68)=1, XX(69)=1, XX(73)=1, XX(74)=2;
INTLC, XX(78)=0, XX(79)=0, XX(83)=2, XX(84)=1;
SIMULATE; BEGIN 9
INTLC, XX(1)=10, XX(2)=15, XX(10)=720, XX(31)=1;
INTLC, XX(63)=4, XX(64)=3, XX(69)=2;
INTLC, XX(79)=1, XX(83)=1, XX(84)=0;
SIMULATE; BEGIN 10
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=2, XX(68)=2, XX(69)=1, XX(73)=4, XX(74)=1;
INTLC, XX(78)=2, XX(79)=0, XX(83)=2, XX(84)=1;
SIMULATE; BEGIN 11
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(69)=2, XX(73)=1, XX(74)=2;
INTLC, XX(84)=0;
SIMULATE; BEGIN 12
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=3, XX(68)=1, XX(69)=1, XX(73)=4, XX(74)=1;
INTLC, XX(78)=0, XX(79)=1, XX(83)=1, XX(84)=1;
SIMULATE; BEGIN 13
INTLC, XX(1)=10, XX(2)=15, XX(10)=960;
INTLC, XX(63)=10, XX(74)=2;
INTLC, XX(78)=2, XX(79)=0;
SIMULATE; BEGIN 14
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=2, XX(68)=2, XX(69)=2, XX(73)=1, XX(74)=1;
INTLC, XX(78)=0, XX(79)=1, XX(83)=2, XX(84)=0;
SIMULATE; BEGIN 15
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(69)=1, XX(73)=4, XX(74)=2;
INTLC, XX(84)=1;
SIMULATE; BEGIN 16
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=3, XX(68)=1, XX(69)=2, XX(73)=1, XX(74)=1;
INTLC, XX(78)=2, XX(79)=0, XX(83)=1, XX(84)=0;
SIMULATE; BEGIN 17
INTLC, XX(1)=10, XX(2)=15, XX(10)=720, XX(31)=3, XX(34)=1;
INTLC, XX(63)=4, XX(64)=2, XX(68)=2, XX(69)=1, XX(73)=4, XX(74)=2;
INTLC, XX(79)=0;
SIMULATE; BEGIN 18
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=3, XX(68)=1, XX(69)=2, XX(73)=1, XX(74)=1;
INTLC, XX(78)=0, XX(79)=1, XX(83)=2, XX(84)=1;
SIMULATE; BEGIN 19
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(69)=1, XX(73)=4, XX(74)=2;
INTLC, XX(84)=0;
SIMULATE; BEGIN 20
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=2, XX(68)=2, XX(69)=2, XX(73)=1, XX(74)=1;
INTLC, XX(78)=2, XX(79)=0, XX(83)=1, XX(84)=1;
SIMULATE; BEGIN 21
INTLC, XX(1)=10, XX(2)=15, XX(10)=960;
INTLC, XX(63)=10, XX(74)=2;
INTLC, XX(78)=0, XX(79)=1;

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SIMULATE; BEGIN 22
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=3, XX(68)=1, XX(69)=1, XX(73)=4, XX(74)=1;
INTLC, XX(78)=2, XX(79)=0, XX(83)=2, XX(84)=0;
SIMULATE; BEGIN 23
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(68)=2, XX(73)=1, XX(74)=2;
INTLC, XX(84)=1;
SIMULATE; BEGIN 24
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=2, XX(68)=2, XX(69)=1, XX(73)=4, XX(74)=1;
INTLC, XX(78)=0, XX(79)=1, XX(83)=1, XX(84)=0;
SIMULATE; BEGIN 25
INTLC, XX(1)=10, XX(2)=15, XX(10)=720, XX(31)=1;
INTLC, XX(63)=4, XX(64)=3, XX(68)=2;
INTLC, XX(78)=0, XX(83)=2, XX(84)=1;
SIMULATE; BEGIN 26
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=2, XX(68)=1, XX(69)=1, XX(73)=1, XX(74)=2;
INTLC, XX(78)=2, XX(79)=1, XX(83)=1, XX(84)=0;
SIMULATE; BEGIN 27
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(68)=2, XX(73)=4, XX(74)=1;
INTLC, XX(84)=1;
SIMULATE; BEGIN 28
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=3, XX(68)=2, XX(69)=1, XX(73)=1, XX(74)=2;
INTLC, XX(78)=0, XX(79)=0, XX(83)=2, XX(84)=0;
SIMULATE; BEGIN 29
INTLC, XX(1)=10, XX(2)=15, XX(10)=960;
INTLC, XX(63)=10, XX(74)=1;
INTLC, XX(78)=2, XX(79)=1;
SIMULATE; BEGIN 30
INTLC, XX(1)=40;
INTLC, XX(63)=4, XX(64)=2, XX(68)=1, XX(69)=2, XX(73)=4, XX(74)=2;
INTLC, XX(78)=0, XX(79)=0, XX(83)=1, XX(84)=1;
SIMULATE; BEGIN 31
INTLC, XX(1)=10, XX(2)=50;
INTLC, XX(68)=1, XX(73)=1, XX(74)=1;
INTLC, XX(84)=0;
SIMULATE; BEGIN 32
INTLC, XX(1)=40;
INTLC, XX(63)=10, XX(64)=3, XX(68)=2, XX(69)=2, XX(73)=4, XX(74)=2;
INTLC, XX(78)=2, XX(79)=1, XX(83)=2, XX(84)=1;
FIN;

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Appendix B
FORTRAN Code

INDEX TO FORTRAN LISTINGS

SUBROUTINE CALLS AND LINKAGES 143

REPLACEMENTS FOR SLAM DEFAULT ROUTINES

PROGRAM MAIN 145
SUBROUTINE EVENT 145
FUNCTION USERF 147
SUBROUTINE INTLC 150

CLOCK-RELATED SUBROUTINES

CLOCK 153
FK3 155
CMBT3/CMBT3A 156
FK4/CMBT4/CMBT4A 157
CMBTX 158

MISSION ENTRY SUBROUTINES

STACK 159
REP 162
RESCH 163
MSNTIM 164

SCHEDULING-RELATED SUBROUTINES

SCHED 167
SCHSET 175
DEDKED 178
ETACHK 179
WX 181
WXCHK 183
PTRCHK 185
THREAT 185

GENERAL NETWORK FLOW SUBROUTINES

MMMAIN 186
RESCUE 191
CONTIN 194
RESTRN 200
ENRTE 205
APPRCH 210

TRACE SUBROUTINE

MTRACE 212

SUBROUTINE CALLS AND LINKAGES:

SUBROUTINE	CALLS	CALLED BY	EVENT
APPRCH	DEDHED RESCH	EVENT NODE	6
CLOCK	WX(J) THREAT CLOCK (R)	INTLC CLOCK (R)	7
CMBT3	CMBT3A	FK3	
CMBT3A		CMBT3	11
CMBT4	CMBT4A	FK4	
CMBT4A		CMBT4	12
CMBTX		EVENT NODE	13
CONTIN	DEDHED RESCH	EVENT NODE	4
ENRTE	WXCHK RESCH	EVENT NODE	5
ETACHK		SCHED	
FK3	CMBT3 FK3 (R)	INTLC FK3 (R)	8
FK4	CMBT4 FK4 (R)	INTLC FK4 (R)	9
FTRCHK		WXCHK ENRTE	
MSNTIM		STACK REP(K) RESCH RESCUE	2
MTRACE(I)		EVENT NODE APPRCH CONTIN ENRTE MSNTIM RESTRT RESCUE SCHED	17, 18
MXMAIN		EVENT NODE	10
REP(K)	MSNTIM REP(K) (R)	INTLC REP(K) (R)	19-23
RESCH	MSNTIM	EVENT NODE APPRCH CMBTX CONTIN ENRTE RESCUE RESTRT	14
RESCUE	MSNTIM RESCH	EVENT NODE	15
RESTRT	DEDHED RESCH	EVENT NODE	16
SCHED	DEDHED ETACHK SCHSET WXCHK	EVENT NODE	3

SCHSET		SCHED	
STACK	MSNTIM	INTLC	1
	STACK [R]	STACK [R]	
THREAT		CLOCK	
WXCHK	FTRCHK	APPRCH	
		DEDKED	
		ENRTE	
		INTLC	
		SCHED	
WX(J)		CLOCK	

NOTE: [R] DENOTES SUBROUTINES CALLING/CALLED BY
THEMSELVES (VIA SLAM EVENT CALENDAR)

```

PROGRAM MAIN(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT)
DIMENSION NSET(18000)
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,IX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
COMMON/UCOM2/ ETALST(150)
COMMON QSET(18000)
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,6,2*0,1,3,4,3*0,
:   2,2,1,3*0,2,5*0,2,10,4*0,2,10,6,3*0,2,9,4,3*0,
:   10,9,1,3*0,10,2,4*0,10,5*0,10,6,4*0,10,5,4,3*0,
:   6,10,9,1,2*0,6,10,2,3*0,6,10,4*0,6,5*0,6,5,4,3*0,
:   4,3,1,3*0,4,9,2,3*0,4,5,10,3*0,4,5,6,3*0,4,5*0/
DATA ETELST/ 0, 50, 80,150, 90,
:   50, 0, 60,120,150,
:   80, 60, 0, 60,120,
:   150,120, 80, 0, 90,
:   90,150,120, 80, 0/
DATA BASLST/1,2,3,4,5,
:   2,3,4,1,5,
:   3,2,4,1,5,
:   4,3,2,1,5,
:   5,1,2,3,4/
EQUIVALENCE (NSET(1),QSET(1))
MNSET=18000
NCRDR=5
NPRNT=6
NTAPE=7
CALL SLAM
STOP
END
SUBROUTINE EVENT(IJ)
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,IX(100)
COMMON/UCOM1/ A(40),ETALST(150),ETELST(25),ZONLST(150),
:   BASLST(25),MOGLST(5),MSMETA(10)
GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,
:   19,20,21,22,23),IJ
1  CALL STACK
   RETURN
2  CALL MSNTIM
   RETURN
3  CALL SCHED
   RETURN
4  CALL CONTIN
   RETURN
5  CALL ENRTE
   RETURN
6  CALL APPRCH
   RETURN
7  CALL CLOCK
   RETURN
8  CALL PK3

```

```
      RETURN
9      CALL FK4
      RETURN
10     CALL MMMAIN
      RETURN
11     CALL CMST3A
      RETURN
12     CALL CMST4A
      RETURN
13     CALL CMSTX
      RETURN
14     CALL NESCH
      RETURN
15     CALL RESCUE
      RETURN
16     CALL RESTRT
      RETURN
17     CALL MTRACE(1)
      RETURN
18     CALL MTRACE(4)
      RETURN
19     CALL REP(1)
      RETURN
20     CALL REP(2)
      RETURN
21     CALL REP(3)
      RETURN
22     CALL REP(4)
      RETURN
23     CALL REP(5)
      RETURN
      END
```

```

FUNCTION USERF(IJ)
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
HSTOP,NCLNR,NCRDR,NPRNT,NMRUN,NMSET,NTAPE,SS(100),SSL(100),
TNEXT,TNOW,XX(100)
IF (IJ.EQ.11) GO TO 11
IF (IJ.EQ.12) GO TO 12
IF (IJ.EQ.13) GO TO 13
IF (IJ.EQ.14) GO TO 14
IF (IJ.EQ.31) GO TO 31
IF (IJ.EQ.32) GO TO 32
IF (IJ.EQ.33) GO TO 33
IF (IJ.EQ.34) GO TO 34
IF (IJ.EQ.41) GO TO 41
IF (IJ.EQ.42) GO TO 42
IF (IJ.EQ.43) GO TO 43
IF (IJ.EQ.44) GO TO 44
IF (IJ.EQ.51) GO TO 51
IF (IJ.EQ.52) GO TO 52
C MAIN BASE OFFLOAD
11 IF (ATTRIB(14).EQ.0) USERF=0.
IF (ATTRIB(14).EQ.1) USERF=TRIAG(5.,15.,25.,1)
IF (ATTRIB(14).EQ.2) USERF=TRIAG(15.,30.,45.,1)
IF (ATTRIB(14).EQ.3) USERF=TRIAG(15.,30.,45.,1)
IF (ATTRIB(14).EQ.4) USERF=0.
IF (ATTRIB(14).EQ.5) USERF=TRIAG(20.,30.,40.,1)
IF (ATTRIB(14).EQ.6) USERF=TRIAG(20.,40.,60.,1)
IF (ATTRIB(14).EQ.7) USERF=TRIAG(10.,20.,30.,1)
RETURN
C CREW REST
12 ATRIB(18)=0
CDAY=ATTRIB(1)-ATTRIB(10)
IF (ATTRIB(10).GE.1) CALL COLCT(CDAY,3)
USERF=720-TNOW+ATTRIB(1)
IF (USERF.LE.0) USERF=0
RETURN
C MAIN BASE ONLOAD
13 IF (ATTRIB(13).EQ.0) USERF=10.
IF (ATTRIB(13).EQ.1) USERF=TRIAG(10.,20.,30.,1)
IF (ATTRIB(13).EQ.2) USERF=TRIAG(20.,30.,50.,1)
IF (ATTRIB(13).EQ.3) USERF=TRIAG(30.,45.,75.,1)
IF (ATTRIB(13).GE.4) USERF=TRIAG(30.,60.,90.,1)
RETURN
C MAIN BASE TAXI-OUT
14 ATRIB(34)=TNOW-ATTRIB(4)
ATTRIB(6)=ATTRIB(6)+ATTRIB(34)
ATTRIB(7)=ATTRIB(7)+ATTRIB(34)
ATTRIB(4)=TNOW
IF (ATTRIB(14).GE.4) USERF=15.
IF (ATTRIB(14).LE.3) USERF=TRIAG(5.,10.,20.,1)
RETURN
C BASE 3 40K OFFLOAD
31 IF (ATTRIB(14).EQ.2) USERF=TRIAG(10.,15.,20.,1)
IF (ATTRIB(14).EQ.3) USERF=TRIAG(10.,20.,30.,1)
RETURN

```

```

C BASE 3 FORKLIFT OFFLOAD
32  IF (ATRI(14).EQ.2) USERF=TRIAC(15.,20.,30.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(20.,25.,40.,1)
    RETURN
C BASE 3 40K ONLOAD
33  IF (ATRI(13).EQ.2) USERF=TRIAC(10.,15.,20.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(15.,20.,30.,1)
    IF (ATRI(13).EQ.6) USERF=TRIAC(20.,40.,60.,1)
    RETURN
C BASE 3 FORKLIFT ONLOAD
34  IF (ATRI(13).EQ.2) USERF=TRIAC(10.,25.,40.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(20.,30.,45.,1)
    IF (ATRI(13).EQ.6) USERF=TRIAC(30.,60.,90.,1)
    RETURN
C BASE 4 40K OFFLOAD
41  IF (XX(31).NE.3) THEN
    IF (ATRI(14).EQ.2) USERF=TRIAC(10.,15.,20.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(15.,20.,30.,1)
    ELSE
    IF (ATRI(14).EQ.2) USERF=TRIAC(10.,20.,35.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(15.,25.,40.,1)
    ENDIF
    RETURN
C BASE 4 FORKLIFT OFFLOAD
42  IF (XX(31).NE.3) THEN
    IF (ATRI(14).EQ.2) USERF=TRIAC(10.,15.,20.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(15.,20.,30.,1)
    ELSE
    IF (ATRI(14).EQ.2) USERF=TRIAC(10.,20.,35.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(15.,25.,40.,1)
    ENDIF
    RETURN
C BASE 4 40K ONLOAD
43  IF (XX(31).NE.3) THEN
    IF (ATRI(13).EQ.2) USERF=TRIAC(10.,25.,40.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(20.,30.,45.,1)
    ELSE
    IF (ATRI(13).EQ.2) USERF=TRIAC(20.,30.,45.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(30.,45.,60.,1)
    ENDIF
    RETURN
C BASE 4 FORKLIFT ONLOAD
44  IF (XX(31).NE.3) THEN
    IF (ATRI(13).EQ.2) USERF=TRIAC(10.,25.,40.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(20.,30.,45.,1)
    ELSE
    IF (ATRI(13).EQ.2) USERF=TRIAC(20.,30.,45.,1)
    IF (ATRI(13).EQ.3) USERF=TRIAC(30.,45.,60.,1)
    ENDIF
    RETURN
C BASE 5 OFFLOAD
51  IF (XX(31).NE.3) THEN
    IF (ATRI(14).EQ.2) USERF=TRIAC(15.,20.,30.,1)
    IF (ATRI(14).EQ.3) USERF=TRIAC(20.,30.,40.,1)

```

```

ELSE
  IF (ATTRIB(14).EQ.2) USERF=TRIAG(20.,25.,35.,1)
  IF (ATTRIB(14).EQ.3) USERF=TRIAG(25.,35.,50.,1)
ENDIF
RETURN
C BASE 5 ONLOAD
52  IF (XX(31).NE.3) THEN
      IF (ATTRIB(13).EQ.2) USERF=TRIAG(10.,25.,40.,1)
      IF (ATTRIB(13).EQ.3) USERF=TRIAG(20.,30.,45.,1)
    ELSE
      IF (ATTRIB(13).EQ.2) USERF=TRIAG(20.,30.,45.,1)
      IF (ATTRIB(13).EQ.3) USERF=TRIAG(30.,45.,60.,1)
    ENDIF
  RETURN
END

```

```

SUBROUTINE INTLC
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),SSL(100),
: TNEXT,TNOW,XX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
REAL A(40)
INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST,MSNETA
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,8,2*0,1,3,4,3*0,
: 2,2,1,3*0,2,5*0,2,10,4*0,2,10,8,3*0,2,9,4,3*0,
: 10,9,1,3*0,10,2,4*0,10,5*0,10,8,4*0,10,5,4,3*0,
: 8,10,9,1,2*0,8,10,2,3*0,8,10,4*0,8,5*0,8,5,4,3*0,
: 4,3,1,3*0,4,8,2,3*0,4,5,10,3*0,4,5,8,3*0,4,5*0/
DATA ETELST/ 0, 50, 80,150, 90,
: 50, 0, 60,120,150,
: 80, 60, 0, 60,120,
: 150,120, 60, 0, 90,
: 90,150,120, 90, 0/
DATA BASLST/1,2,3,4,5,
: 2,3,4,1,5,
: 3,2,4,1,5,
: 4,3,2,1,5,
: 5,1,2,3,4/
C INITIALIZE VARIABLES
DO 2 I=1,40
A(I)=0
ATTRIB(I)=0
2 CONTINUE
C BASE 3 RESOURCE SETUP
C MOG3 (MAX ACFT ON GND)
10 CALL ALTER(1,-1)
DO 30 I=1,XX(63)
CALL ALTER(1,1)
30 CONTINUE
C ATC3 (MAX ACFT ON APPROACH/DEPARTURE)
CALL ALTER(2,-1)
DO 31 I=1,XX(88)
CALL ALTER(2,1)
31 CONTINUE
C K3 (40K LOADER SETUP)
CALL ALTER(3,-1)
DO 32 I=1,XX(76)
CALL ALTER (3,1)
32 CONTINUE
C FK3 (FORKLIFT SETUP: IF XX(35)=1, FK3/CMET3/CMET3A ENABLED)
ATTRIB(1)=2
CALL ALTER(4,-1)
DO 34 I=1,XX(73)
CALL ALTER(4,1)
IF (XX(35).EQ.1) CALL SCHDL(0,0.,ATTRIB)
34 CONTINUE
C BASE 4 SETUP (IDENTICAL TO BASE 3)
C MOG4 (MAX ACFT ON GND)
CALL ALTER(5,-1)
DO 40 I=1,XX(84)

```



```

        CALL ALTER(5,1)
40    CONTINUE
C ATC4 (MAX ACFT ON APPROACH/DEPARTURE)
        CALL ALTER(6,-1)
        DO 41 I=1,XX(69)
            CALL ALTER(6,1)
41    CONTINUE
C K4 (40K LOADER SETUP)
        CALL ALTER(7,-1)
        DO 42 I=1,XX(79)
            CALL ALTER (7,1)
42    CONTINUE
C FK4 (FORKLIFT SETUP: IF XX(35)=1, FK4/CMBT4/CMBT4A ENABLED)
        ATRIB(1)=2
        CALL ALTER(8,-1)
        DO 44 I=1,XX(74)
            CALL ALTER(8,1)
            IF (XX(35).EQ.1) CALL SCHDL(9,0.,ATRIB)
44    CONTINUE
C TIME-OF-DAY CLOCK SETUP
        ATRIB(1)=0
        CALL SCHDL(7,0.,ATRIB)
        IF (XX(26).GE.24) XX(26)=XX(26)-24
        XX(26)=XX(26)
C DAY-NIGHT CLOCK SETUP (SPECIFY HOURS OF DAYLIGHT DEP ON SEASON)
        IF (XX(31).EQ.1) XX(26)=20
        IF (XX(31).EQ.2.OR.XX(31).EQ.4) XX(26)=14
        IF (XX(31).EQ.3) XX(26)=8
C AIRCRAFT GENERATOR
        ATRIB(1)=0
        ATRIB(2)=1
        ATRIB(9)=1
        ATRIB(10)=0
        ATRIB(12)=1
        ATRIB(15)=1
        ATRIB(16)=1
        DO 51 I=1,XX(1)
            CALL ENTER(3,ATRIB)
            ATRIB(9)=ATRIB(9)+1
51    CONTINUE
C CREW GENERATOR
        DO 52 I=1,XX(2)
            CALL FILEM(7,ATRIB)
52    CONTINUE
C WEATHER SETUP
        IF (XX(34).EQ.1) THEN
            DO 53 I=41,50
                XX(I)=1
53    CONTINUE
            ENDIF
C INITIALIZE RUN TERMINATION VARIABLES
        DO 54 K=20,25
            XX(K)=0
54    CONTINUE

```

C CALL MISSION ENTRY SUBROUTINES

CALL SCHDL(19,0.,ATRIE)

CALL SCHDL(20,0.,ATRIE)

CALL SCHDL(21,0.,ATRIE)

CALL SCHDL(22,0.,ATRIE)

CALL SCHDL(23,0.,ATRIE)

CALL SCHDL(1,0.,ATRIE)

RETURN

END

```

SUBROUTINE CLOCK
C THE CLOCK KEEPS "REAL TIME" BASED ON THE START TIME ENTERED
C BY THE USER (DEFAULT = MIDNIGHT). GIVEN A START TIME, THE
C CLOCK INCREMENTS EVERY HOUR AND RETURNS THE TWO-DIGIT HOUR
C IN XX(26). THE CLOCK KEEPS TRACK OF CALENDAR DAYS
C FROM START OF SIMULATION (START OF SIMULATION IS DAY 1,
C AND BECOMES DAY 2 AT THE NEXT MIDNIGHT, ETC.) AND RETURNS
C THE VALUE IN XX(30). THE CLOCK ALSO KEEPS TRACK OF DAYTIME
C AND NIGHTTIME, BASED ON THE SEASON; DAY/NIGHT IS RETURNED IN
C XX(27).
C IF THE VARIABLE-WEATHER SWITCH IS SET, THE CLOCK CALLS
C THE WEATHER MARKOV SUBROUTINE EVERY SIX HOURS BEGINNING AT
C 0300. EACH MIDNIGHT, THE CLOCK ALSO CALLS FOR A THREAT
C UPDATE FOR THE NEXT 24 HOURS. WEATHER AND THREAT VALUES
C RETURNED FOR EACH ZONE IN XX(41) THROUGH XX(80).
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
INTEGER TDAY,DAY,DAYTIM
EQUIVALENCE (XX(26),TDAY)
EQUIVALENCE (XX(27),DAYTIM)
EQUIVALENCE (XX(30),DAY)
NIGHT=24-XX(28)
C IF NOT CALLED BY INTLC, INCR TDAY BY ONE HOUR, CHECK FOR
C PAST MIDNIGHT; UPDATE THREAT AT MIDNIGHT IF SWITCH SET
IF (ATRIB(1).EQ.1) THEN
    TDAY=TDAY+1
    IF (TDAY.GE.24) TDAY=0
    IF (TDAY.EQ.0) THEN
        DAY=DAY+1
        IF (XX(37).EQ.2) CALL THREAT
    ENDIF
C IF SWITCH SET, CALL WX UPDATES AT 3, 9, 15, AND 21
IF (XX(34).EQ.2) THEN
    IF (TDAY.EQ.3.OR.TDAY.EQ.9.OR.
: TDAY.EQ.15.OR.TDAY.EQ.21) THEN
        DO 10 I=1,10
            CALL WX(I)
10        CONTINUE
    ENDIF
ENDIF
C INITIAL CALL (ATRIB(1)=0)
IF (ATRIB(1).EQ.0) THEN
    DAY=1
    IF (XX(37).EQ.2) CALL THREAT
    ATRIB(1)=1
ENDIF
C UPDATE DAY/NIGHT FLAG IF SWITCH SET
IF (XX(32).EQ.1) THEN
    SUNRISE=NIGHT/2
    SUNSET=24-NIGHT/2
    IF (TDAY.GE.SUNRISE.AND.TDAY.LE.SUNSET) THEN
        DAYTIM=1
    
```

```

ELSE
  DAYTIM=0
ENDIF
ENDIF
CALL SCHDL(7,60.,ATRI8)
IF XX(99).GE.1) PRINT 1000, TNOW, DAY, TDAY, DAYTIM
RETURN
1000 FORMAT (1X,F7.1,' DAY ',12,',', HOUR ',12,': DAY/NIGHT=',11)
C12345.7 DAY 12, HOUR 23: DAY/NIGHT=1
END

```

```

C MASTER CLOCK FOR BASE 3 FORKLIFTS -- EACH MACHINE UP FOR AVG
C OF 18 HRS, DOWN AVG 4 HRS TO REPAIR. XX(73) IS USER-SET FK3
C LEVEL; INTLC GENERATES CORRECT NO. OF FKLIPTS AND REDUCES
C CAPACITY TO ZERO (PGM BEGINS WITH DEFAULT OF AT LEAST ONE
C FOR EACH RESOURCE). AS EACH FKLIPT ENTERS SYSTEM, FK3
C CAPACITY IS INCREASED BY ONE TO GIVE PROPER LEVEL. WHEN
C MACHINE FAILS, FK3 LEVEL IS DECREASED BY ONE. WHEN REPAIRS
C ARE COMPLETE, FK3 LEVEL IS AGAIN INCREASED. XX(73) CHANGES
C WHENEVER FK3 LEVEL CHANGES AND REFLECTS CURRENT NUMBER OF
C FK3 IN SERVICE. (INITIAL ENTRIES INTO SYSTEM DO NOT CHANGE
C XX(73) -- IF XX(73) WERE SET TO ZERO AFTER GENERATION, TIME-
C PERSISTENT STATS ON XX(73) WOULD REFLECT A FALSE ZERO LEVEL,
C WHICH WOULD REFLECT IN 'MINIMUM VALUE' COLUMN OF OUTPUT.)
C A1=0 FOR FORKLIFT GOING OUT OF COMMISSION,
C A1=1 FOR FORKLIFT FINISHING REPAIRS
C A1=2 FOR INITIAL ENTRIES (TO PREVENT CHANGING XX(73))
      SUBROUTINE FK3
      COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
      : MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,MNSET,NTAPE,SS(100),
      : SSL(100),TNEXT,TNOW,XX(100)
C IF FLAG SET, FIX RESOURCES AT INITIAL LEVEL (BYPASS CLOCK --
C IF NOT TRIGGERED INITIALLY, WILL NOT BE RESCHEDULED)
      IF (XX(35).EQ.0) RETURN
C COMING-INTO-SERVICE SECTION (A1=1 OR 2)
      IF (ATRI(1).NE.0) THEN
        TSVC=RNORM(1080.,120.,1)
        IF (ATRI(1).EQ.1) XX(73)=XX(73)+1
        IF (ATRI(1).EQ.1) CALL ALTER(4,1)
        ATRI(1)=0
        CALL SCHDL(8,TSVC,ATRI)
        RETURN
      ENDIF
C GOING-OUT-OF-COMMISSION SECTION (A1=0); (ENABLE COMBAT OFFLOAD
C IF ALL FORKLIFTS ARE OUT OF SERVICE)
      XX(73)=XX(73)-1
      CALL ALTER(4,-1)
      IF (XX(73).EQ.0) CALL CMBT3
      TFIX=RNORM(240.,60.,1)
      ATRI(1)=1
      CALL SCHDL(8,TFIX,ATRI)
      RETURN
      END

```

C COMBAT OFFLOAD ENABLE -- IF ALL FORKLIFTS BREAK, ALL ACFT
 C AWAITING FKLFT FOR OFFLOAD START COMBAT OFFLOAD (UNLOAD CARGO
 C ON RAMP AND DEPART). RAMP SPACE IS THEN BLOCKED UNTIL CARGO
 C CAN BE DRAGGED AWAY BY TRUCKS, ETC. -- WHILE RAMP IS BLOCKED,
 C MOC IS DECREASED ACCORDINGLY TO PREVENT MORE ACFT LANDING.
 C SUBSEQUENT AIRCRAFT WILL AUTOMATICALLY USE COMBAT OFFLOAD
 C AS LONG AS XX(73)=0. ACFT AWAITING FKLFT FOR ONLOAD ARE
 C HELD FOR MAX OF 2 HRS, THEN RELEASED IF AT LEAST ONE FKLFT
 C HAS NOT RETURNED TO COMMISSION. INBOUND MISSIONS ARE NOT
 C DIVERTED.

SUBROUTINE CMBT3

COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
 : MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,NMSET,NTAPE,SS(100),SSL(100),
 : TNEXT,TNOW,XX(100)
 INQ11=MNQ(11)
 INQ13=MNQ(13)
 IF (INQ11.GE.1) THEN
 DO 30 I=1,INQ11
 CALL RMOVE(1,II,ATRIB)
 CALL ENTER(31,ATRIB)
 30 CONTINUE
 ENDIF

C ALLOW AIRCRAFT IN FORKLIFT ONLOAD QUEUE TWO HOURS TO SEE IF
 C A FORKLIFT RETURNS TO SERVICE. CALL CMBT3A IN 2 HOURS --
 C IF A FORKLIFT IS BACK IN SERVICE OR IF NO ACFT ARE IN THE
 C ONLOAD QUEUE, NO ACTION WILL BE TAKEN. IF ACFT ARE IN THE
 C ONLOAD QUEUE AND NO FORKLIFTS HAVE RETURNED TO SERVICE,
 C CMBT3A WILL RE-ENTER AFFECTED ACFT IN ONLOAD NET SUCH THAT
 C THEY WILL FIRST TRY TO SEIZE A K-LOADER BEFORE BEING ROUTED
 C TO CMBTX, WHICH WILL ABORT THE MISSION.

CALL SCHDL(11,120.,ATRIB)
 IF (XX(99).GE.1) PRINT 300,TNOW,INQ11,INQ13
 RETURN
 300 FORMAT (1X,F7.1,' COMBAT OFFLOAD 3: OFFLOAD QUEUE = ',I2,
 * ' ONLOAD QUEUE = ',I2)
 END

SUBROUTINE CMBT3A

COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
 : MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,NMSET,NTAPE,SS(100),SSL(100),
 : TNEXT,TNOW,XX(100)
 INQ=MNQ(13)
 IF (INQ.EQ.0.OR.XX(73).GE.1) GO TO 500
 DO 10 I=1,INQ
 CALL RMOVE (1,I3,ATRIB)
 CALL ENTER (3,ATRIB)
 10 CONTINUE
 500 RETURN
 END

```

C FK3 SEQUENCE IS DUPLICATED FOR BASE 4 BY FK4/CMBT4/CMBT4A
SUBROUTINE FK4
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,XX(100)
IF (XX(35).EQ.0) RETURN
IF (ATTRIB(1).NE.0) THEN
    TSVC=EXPON(1000.,1)
    IF (ATTRIB(1).EQ.1) XX(74)=XX(74)+1
    IF (ATTRIB(1).EQ.1) CALL ALTER(8,1)
    ATRIB(1)=0
    CALL SCHDL(9,TSVC,ATTRIB)
    RETURN
ENDIF
XX(74)=XX(74)-1
CALL ALTER(8,-1)
IF (XX(74).EQ.0) CALL CMBT4
TFIX=EXPON(400.,1)
ATTRIB(1)=1
CALL SCHDL(9,TFIX,ATTRIB)
RETURN
END

SUBROUTINE CMBT4
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,XX(100)
INQ18=NNQ(18)
INQ20=NNQ(20)
IF (INQ18.GE.1) THEN
    DO 30 I=1,INQ18
        CALL RMOVE(1,18,ATTRIB)
        CALL ENTER(2,ATTRIB)
30    CONTINUE
ENDIF
CALL SCHDL(12,120.,ATTRIB)
IF (XX(99).GE.1) PRINT 300,TNOW,INQ18,INQ20
RETURN
300  FORMAT (1X,F7.1,' COMBAT OFFLOAD 4: OFFLOAD QUEUE = ',I2,
*      ' ONLOAD QUEUE = ',I2)
END

SUBROUTINE CMBT4A
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,XX(100)
INQ=NNQ(20)
IF (INQ.EQ.0.OR.XX(74).GE.1) GO TO 500
DO 10 I=1,INQ
    CALL RMOVE (1,20,ATTRIB)
    CALL ENTER (4,ATTRIB)
10  CONTINUE
500  RETURN
END

```

```

SUBROUTINE CMETX
C CALLED WHEN ACFT AWAITING FORKLIFT FOR ONLOAD AT BASE 3 OR 4
C CANNOT SECURE EITHER FORKLIFT OR K-LOADER FOR ONLOAD. FOR PMC
C AND PMC AIRCRAFT, SCHEDULED MISSIONS ARE RE-ENTERED IN THE
C MISSION FILE AND AIRCRAFT ARE ROUTED BACK TO THE SCHEDULER
C FOR POSSIBLE RE-SCHEDULING FOR A MISSION NOT REQUIRING MME.
C FOR AIRCRAFT ALREADY IN ABORT STATUS (SHUTDOWN ABORT WITH A
C HOMEBOUND LOAD), ONBOARD MISSIONS ARE RE-ENTERED IN THE
C MISSION FILE AND AIRCRAFT ARE ROUTED DIRECTLY TO RESTART
C EVENT FOR RETURN (EMPTY) TO HOME BASE, WITH ABORT STATUS 2.
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,NMSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
NACFT=ATRIB(9)
LOC=ATRIB(12)
MSN=ATRIB(37)
IF (XX(98).GE.1) PRINT *, ' CMETX AT ',LOC,' -- MSN=',
: MSN,' ACFT# ',NACFT
C SHIFT MISSION ATRIS FOR RE-ENTRY INTO MISSION FILE BY RESCH
DO 10 K=32,23,-1
    ATRIB(K)=ATRIB(K-3)
10 CONTINUE
    ATRIB(20)=ATRIB(12)
    ATRIB(21)=ATRIB(13)
    ATRIB(22)=ATRIB(14)
    ATRIB(23)=ATRIB(15)
    CALL RESCH
    ATRIB(13)=0
    ATRIB(14)=0
    ATRIB(15)=LOC
    ATRIB(16)=0
    IF (ATRIB(2).EQ.3) THEN
        ATRIB(37)=70000+LOC*1000+XX(30)*100+XX(28)
        ATRIB(11)=2
        ATRIB(18)=1
        ATRIB(15)=1
        ATRIB(20)=1
        RETURN
    ENDIF
    RETURN
END

```


C STACK IS THE MAIN MISSION ENTRY ROUTINE. WHEN CALLED.
 C IT WILL MAKE ONE PASS THROUGH EXTERNAL FILE MSTACK
 C AND ENTER ALL MISSIONS WITH READY TIMES EQUAL TO
 C TNOW INTO MSNTIM, WHICH IN TURN WILL FILE THE
 C MISSIONS IN THE PROPER MISSION FILES. WHEN MAKING
 C THE ENTRY PASS, THE TIME FOR THE NEXT PASS IS FOUND
 C AND STACK IS SCHEDULED FOR THAT TIME. IF NO MORE
 C ENTRIES (TNEXT=99999) THE ROUTINE WILL PRINT AN
 C INFORMATION MESSAGE.

C
 C ENTRIES FOR STACK MUST BE IN FILE NAME "MSTACK"
 C (SEE EXAMPLE LISTING IN APPENDIX C). STACK USES A
 C COMPRESSED ENTRY FORMAT TO SAVE SPACE IN THE EXTERNAL
 C FILE. STACK WILL CONVERT THIS FORMAT INTO THE MISSION
 C ENTITY ATTRIBUTE FORMAT LISTED IN TABLE III. (FOR REP
 C ENTRIES, SET MISSION ATTRIBUTES DIRECTLY USING THE
 C TABLE III FORMAT.) MSTACK CAN HAVE A MAXIMUM OF 500
 C MISSIONS.

C
 C MSTACK FORMAT:

C
 C 1 - READY TIME (IN MINUTES FROM SIMULATION START)
 C 2 - TYPE ACFT REQUIRED (FMC OR PMC - 1 OR 2)
 C 3 - MISSION NO. (5-DIGIT INTEGER 10000 TO 59999)
 C 4 - MISSION RISK LEVEL (0, 1, OR 2)
 C 5 - MISSION PRIORITY (1 HIGHEST, 999 LOWEST)
 C 6 - ORIGINATING BASE
 C 7 - FIRST LEG ONLOAD TYPE
 C 8 - FIRST LEG OFFLOAD TYPE
 C 9 - FIRST DESTINATION BASE
 C 10 - SECOND LEG ONLOAD TYPE
 C 11 - SECOND LEG OFFLOAD TYPE
 C 12 - SECOND DESTINATION BASE
 C 13-15 - THIRD LEG DATA
 C 16-18 - FOURTH LEG DATA

C
 C UNUSED DATA SLOTS MUST BE FILLED WITH ZEROS. EXAMPLE:

C
 C 2345 1 45003 2 1 1 2 2 3 2 2 4 0 0 0 0 0 0

C
 C BASE CODES (LOCATIONS LISTED WERE USED FOR THESIS):

C
 C 1 - HOME BASE (ANCHORAGE/ELMENDORF)
 C 2 - MAIN BASE (FAIRBANKS/WAINWRIGHT/IELSON)
 C 3 - FORWARD FIGHTER ALERT BASE (GALENA)
 C 4 - FORWARD AIRHEAD (GRANITE MOUNTAIN)
 C 5 - GCI SITE (CAPE NEWENHAM)

C
 C LOAD TYPE CODES:

C
 C 0 - NO LOAD
 C 1 - NON-MHE (PERSONNEL AND/OR ROLLING STOCK)
 C 2 - MHE (3 OR FEWER PALLETS)
 C 3 - MHE (4 OR MORE PALLETS)
 C 4 - (NOT USED)

```

C      5 - PERSONNEL AIRDROP (NON-MHE)
C      6 - CARGO AIRDROP (MHE NEEDED)
C
C      IMPORTANT: DO NOT ENTER MISSIONS WITH BASE OR LOAD
C      CODES OTHER THAN THOSE LISTED ABOVE OR THE MODEL
C      WILL NOT EXECUTE PROPERLY.
C
C      THE MODEL ALSO USES THESE INTERNAL LOAD CODES (NOT FOR
C      MISSION-ENTRY USE):
C
C      7 - COMPLETED AIRDROP RETURN TO HOME BASE
C      8 - "RESCUE" MISSION MAINTENANCE PACKAGE
C
C
C      SUBROUTINE STACK
C      COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
C      :      MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),
C      :      SSL(100),TNEXT,TNOW,XX(100)
C      REAL A(40),T,TNXT
C      INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST,MSNETA,B(18)
C      INITIALIZE ATRIB ARRAYS (A=STD FORMAT, B=MSTACK FORMAT)
C      DO 10 I=1,40
C          A(I)=0
C      10  CONTINUE
C      DO 11 I=1,18
C          B(I)=0
C      11  CONTINUE
C      OPEN MSTACK FOR INPUT
C      OPEN (50,ERR=900,FILE='STACK',ACCESS='SEQUENTIAL')
C      REWIND 50
C      TNXT=99999
C      DO 100 I=1,500
C          READ (50,*,ERR=901,END=200) (B(J),J=1,18)
C          T=B(1)
C          IF (T.LT.0) T=0
C      C ENTER MISSION IF READY (CONVERT "B" TO "A")
C          IF (T.EQ.TNOW) THEN
C              DO 20 M=1,5
C                  A(M)=B(M)
C      20  CONTINUE
C              DO 30 K=6,18
C                  A(K+14)=B(K)
C      30  CONTINUE
C              CALL SCHDL(2,0.,A)
C              XX(22)=XX(22)+1
C          ENDIF
C      C CHECK FOR NEXT MISSION ENTRY TIME
C          IF (T.GT.TNOW.AND.T.LT.TNXT) TNXT=T
C      100 CONTINUE
C      200 CLOSE(50)
C      C IF NO MORE MISSIONS, PRINT MSG, ENABLE RUN TERMINATION NET;
C          IF (TNXT.EQ.99999) THEN
C              PRINT *, ' STACK EXHAUSTED AT T=',TNOW
C              XX(21)=1
C              RETURN

```

```

        ENDIF
C IF MORE MISSIONS, RESCHEDULE AT TNXT
  TSCHD=TNXT-TNOW
  CALL SCHDL(1,TSCHD,ATRI8)
  RETURN
C ERROR MESSAGE
900  PRINT *, ' STACK ENTRY ERROR AT ',TNOW
901  PRINT *, ' STACK READ ERROR AT ',TNOW
      RETURN
      END

```

```

SUBROUTINE REP(K)
C REP IS A REPETITIVE INPUT ROUTINE FOR ENTERING A NUMBER
C OF MISSIONS WITH THE SAME ATTRIBUTES AT ONCE OR OVER
C A PERIOD OF TIME. IT IS VERY USEFUL FOR TESTING
C PURPOSES. CONSTRUCTION OF VARIOUS REP ROUTINES IS
C LEFT TO THE USER AS REQUIRED.
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,NMSET,NTAPE,SS(100),SSL(100),
: TNEXT,TNOW,XX(100)
GO TO (1,2,3,4,5),K
C REP(1) ENTERS 3 NORMAL RESUPPLY MISSIONS EACH 8 HOURS (ONE EACH
C TO BASES 2, 3, AND 5). REP(1) INPUT STOPS AS SOON AS STACK IS
C EXHAUSTED.
1 IF (XX(21).EQ.0) THEN
CALL SCHDL(10,480.,ATRIE)
DO 11 K=1,40
ATRIE(K)=0
11 CONTINUE
ATRIE(1)=TNOW
ATRIE(2)=2
ATRIE(3)=12000+XX(30)*100+XX(28)
ATRIE(4)=0
ATRIE(5)=1
ATRIE(20)=1
ATRIE(21)=3
ATRIE(22)=3
ATRIE(23)=2
CALL SCHDL(2,0.,ATRIE)
ATRIE(3)=ATRIE(3)+1000
ATRIE(23)=3
CALL SCHDL(2,0.,ATRIE)
ATRIE(3)=ATRIE(3)+2000
ATRIE(2)=1
ATRIE(5)=5
ATRIE(21)=2
ATRIE(22)=2
ATRIE(23)=5
CALL SCHDL(2,0.,ATRIE)
XX(22)=XX(22)+3
ENDIF
RETURN
2 RETURN
3 RETURN
4 RETURN
5 RETURN
END

```

SUBROUTINE RESCH

C WHEN AN AIRCRAFT CANNOT CONTINUE ITS SCHEDULED MISSION,
 C A CONTINUATION MISSION MUST BE CREATED. IF THE MISSION
 C HAS NOT YET BEEN PICKED UP (AIRCRAFT ON POSITION LEG)
 C THE MISSION IS IMMEDIATELY REENTERED IN THE APPROPRIATE
 C MISSION FILE. IF AN AIRCRAFT WITH A LOAD ABORTS, ITS
 C FUTURE MISSION DATA SLOTS (A20-A32) ARE SET UP TO BECOME
 C THE CONTINUATION MISSION ON RETURN TO HOME BASE. IF AN
 C AIRCRAFT IS GROUNDED AT AN ENROUTE BASE, IT MUST BE OFFLOADED
 C AND AN APPROPRIATE CONTINUATION MISSION ENTERED FOR ORIGINA-
 C TION AT THAT BASE. IN ANY CASE, THE RE-ENTRY OF THE
 C CONTINUATION MISSION IS SIMPLY RECREATION OF A MISSION WITH
 C ATTRIBUTES A20-A32 IN THE ITINERARY SLOTS AND A35-A39 IN
 C THE MISSION IDENTIFICATION SLOTS (A1-A5). ALL RE-ENTERED
 C MISSIONS HAVE THEIR ORIGINAL PRIORITY AND READY TIME,
 C AND SO WILL RECEIVE HIGH PRIORITY IN THE MISSION FILE.

COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,

: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),

: SSL(100),TNEXT,TNOW,IX(100)

REAL A(40)

DO 3 I=1,40

A(I)=0

5 CONTINUE

C RECREATE THE MISSION

DO 10 I=20,32

A(I)=ATRIE(I)

10 CONTINUE

DO 11 I=1,5

A(I)=ATRIE(34+I)

11 CONTINUE

CALL MTRACE(50)

CALL SCHDL(2,0.,A)

C CLEAN UP ACFT ATRIE

DO 20 I=19,40

ATRIE(I)=0

20 CONTINUE

ATRIE(11)=2

RETURN

END

C MSNTIM -- ESTIMATES MISSION DURATION FOR INITIALLY-ENTERED
 C MISSIONS
 C
 C INPUT -- ATTRIB ATTRIBUTE SET FOR MISSION ENTITY
 ETELST ENRTE FLYING TIME (ETE) LOOKUP TABLE
 C OUTPUT -- ATTRIB UPDATED ATTRIBUTE LIST, SPECIFICALLY:
 33-36 EST ARRIVAL TIMES AT DESTINATIONS
 (TIMES ELAPSED AFTER START OF
 INITIAL ONLOAD)
 38 EST MSN DURATION (INCLUDING TIME
 FOR RETURN LEG TO HOME BASE IF
 LAST DEST IS NOT HOME BASE)
 C INTERNAL -- LEG LEG COUNTER
 ORIG LEG START BASE CODE
 DEST LEG END BASE CODE
 ONCGO ONLOAD CARGO TYPE CODE
 OFFCGO OFFLOAD CARGO TYPE CODE
 ETE FLYING TIME BETWEEN 2 BASES FROM ETELST
 MTIM MISSION DURATION ACCUMULATOR
 C
 C 1. INITIALIZE MTIM (ACCUMULATOR) TO ZERO.
 C 2. FOR EACH LEG OF THE MISSION:
 C A. IF NO MORE LEGS, SEE IF EXTRA LEG IS NEEDED TO RETURN
 HOME
 C B. GET CURRENT LEG DATA FROM ATTRIB FILE
 C C. INCREMENT MTIM FOR:
 ONLOAD (BASED ON LOAD TYPE)
 ORIG BASE (EXTRA TAXI TIME FOR MAIN BASES)
 FLYING TIME (FROM ORIG TO DEST)
 C D. SET ETA AT DEST BASE (ATTRIBS 33-36)
 C E. INCREMENT MTIM FOR OFFLOAD AT DEST (BASED ON LOAD TYPE)
 C F. REPEAT FOR NEXT ZONE
 C 3. IF LAST DESTINATION WAS HOME BASE, EXTRA LEG IS NOT NEEDED.
 C IF LAST DESTINATION WAS NOT HOME BASE, ADD TIME FOR
 C RETURN TO HOME BASE.
 C 4. SET ATTRIB(38) TO ACCUMULATED ESTIMATED MISSION DURATION.
 C
 C NOTES: TIMES APPROXIMATE RULE-OF-THUMB TIMES WHICH WOULD BE USED BY
 C SCHEDULER IN CHECKING FOR SLOTS AT ENROUTE BASES, CREW
 C DUTY DAY LENGTHS, ETC.
 C LEG TO HOME BASE IS ADDED BECAUSE CREWS CAN ONLY BE CHANGED
 C AT HOME BASE; CREW DAY REMAINING MUST INCLUDE TIME TO GET
 C HOME.
 C HOLDING FOR WEATHER OR TRAFFIC (EITHER IN AIR OR ON GROUND)
 C IS NOT PLANNED FOR ANY STATION; MISSION IS PLANNED FOR
 C STRAIGHT-THROUGH EXECUTION ONCE BEGUN. (INITIAL
 C DEPARTURE DELAYS MAY BE AUTHORIZED WHEN THE MISSION IS
 C ACTUALLY SCHEDULED.)
 C MAIN BASE DEPARTURES REQUIRE 10 MINUTES EXTRA TAXI TIME DUE
 C TO LONGER DISTANCES.
 C AIRDROP MISSIONS (CARGO CODES 5-6) ARE ASSUMED TO REQUIRE
 C EXTRA BRIEFING AND LOADING TIME. AIRDROPS REQUIRE AN
 C EXTRA 10 MIN AT DEST BASE FOR LINEUP, RUN-IN, SLOWDOWN,
 C DROP, AND INITIATION. (AIRDROPS REQUIRE NO ADDITIONAL
 C TIME AT DEST.)

C MINIMUM GROUND TIME AT ANY DESTINATION IS 15 MINUTES (INCLUDED
 C IN ONLOAD TIME).
 C ENROUTE TIMES ARE AVERAGE TIMES FROM TAKEOFF TO LANDING,
 C INCLUDING APPROACH, FOR MISSIONS FLOWN USING COMPOSITE
 C OF HIGH AND LOW LEVEL TACTICS.
 C

```

SUBROUTINE MSNTIM
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),
: TNEXT,TNOW,XX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST,MSNETA,ORIG,DEST,
ONCGO,OFFCGO
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,8,2*0,1,3,4,3*0,
: 2,2,1,3*0,2,5*0,2,10,4*0,2,10,6,3*0,2,9,4,3*0,
: 10,9,1,3*0,10,2,4*0,10,5*0,10,6,4*0,10,5,4,3*0,
: 6,10,9,1,2*0,6,10,2,3*0,6,10,4*0,6,5*0,6,5,4,3*0,
: 4,3,1,3*0,4,9,2,3*0,4,5,10,3*0,4,5,8,3*0,4,5*0/
DATA ETELST/ 0, 50, 80,150, 90,
: 50, 0, 60,120,150,
: 80, 60, 0, 60,120,
: 150,120, 80, 0, 90,
: 90,150,120, 90, 0/
DATA BASLST/1,2,3,4,5,
: 2,3,4,1,5,
: 3,2,4,1,5,
: 4,3,2,1,5,
: 5,1,2,3,4/
C INITIALIZE MTIM, THEN LOOP THROUGH EACH LEG
MTIM=0
DO 10 LEG=1,4
C IF DEST IS ZERO, NO MORE LEGS; CHECK FOR EXTRA LEG TO HOME BASE
IF (ATTRIB(LEG*3+20).EQ.0) GO TO 20
C LOAD DATA FOR THIS LEG
ORIG=ATTRIB(LEG*3+17)
ONCGO=ATTRIB(LEG*3+18)
OFFCGO=ATTRIB(LEG*3+19)
DEST=ATTRIB(LEG*3+20)
C INCREMENT MTIM FOR ONLOAD
IF (ONCGO.EQ.0) MTIM=MTIM+15
IF (ONCGO.EQ.1) MTIM=MTIM+30
IF (ONCGO.EQ.2) MTIM=MTIM+45
IF (ONCGO.EQ.3) MTIM=MTIM+45
IF (ONCGO.EQ.4) MTIM=MTIM+60
C INCREMENT MTIM FOR MAIN-BASE TAXI TIME
IF (ORIG.LE.2) MTIM=MTIM+10
C INCREMENT MTIM FOR ENROUTE TIME
ETE=ETELST((ORIG-1)*5+DEST)
MTIM=MTIM+ETE
C NOTE ELAPSED TIME TO THIS BASE
ATTRIB(LEG+32)=MTIM
C INCREMENT MTIM FOR OFFLOAD
IF (OFFCGO.EQ.1) MTIM=MTIM+15
IF (OFFCGO.EQ.2) MTIM=MTIM+30
IF (OFFCGO.EQ.3) MTIM=MTIM+30
  
```

```

        IF (OFFCGO.GE.5) MTIM=MTIM+10
10      CONTINUE
C ADD TIME FOR RETURN TO MAIN BASE, IF NEEDED
20      IF (DEST.EQ.1) THEN
          ATRIB(38)=MTIM
          GO TO 30
        ENDIF
        ATRIB(38)=MTIM+ETELST((DEST-1)*5+1)
30      MSNQ=ATRIB(20)
        CALL FILEM(MSNQ,ATRIB)
        CALL MTRACE(7)
        CALL MTRACE(50)
        RETURN
      END

```


C SCHED IS THE MASTER SCHEDULER FOR THE NETWORK. WHEN
 C TRIGGERED BY AN AIRCRAFT ARRIVAL, IT NOTES THE LOCATION
 C OF THE AIRCRAFT (A12) AND BEGINS TO CHECK FOR POSSIBLE
 C MISSIONS IN EACH BASE MISSION FILE, BEGINNING WITH THE
 C CURRENT BASE AND FOLLOWING THE PRESET SEARCH SEQUENCE
 C IN BASLST. FOR EACH BASE EXAMINED, THE SCHEDULER FIRST
 C CHECKS TO SEE IF A POSITION LEG IS REQUIRED (AIRCRAFT
 C REQUIRED TO FLY EMPTY TO MISSION ORIGINATION BASE).
 C IF A POSITION LEG IS NEEDED, THE SCHEDULER CHECKS FOR
 C ENROUTE AND TERMINAL WEATHER, THREAT, AND AIRCRAFT STATUS.
 C THE MISSION FILE FOR THAT BASE IS CHECKED ONLY FOR MISSIONS
 C REQUIRING THREAT RISK EQUAL TO OR GREATER THAN THAT WHICH
 C WOULD BE NEEDED TO FLY THE POSITION LEG. (I.E., THE MISSION
 C WON'T BE SCHEDULED IF IT'S NOT WORTH THE RISK TO GET THERE
 C TO PICK IT UP.)

C WITHIN EACH MISSION FILE, MISSIONS ARE EXAMINED ON A
 C HIGHEST-PRIORITY FIRST BASIS (NORMAL FILE RANKING CRITERIA).
 C WITHIN A GIVEN PRIORITY, MISSIONS ARE EXAMINED ON A BASIS
 C OF OLDEST READY TIME FIRST. EACH PROSPECTIVE MISSION IS
 C RUN THROUGH A SERIES OF SCREENING CHECKS TAILORED FOR
 C VARIOUS LOCATIONS AND CASES, AND A MISSION IS SCHEDULED
 C IF IT IS NOT ELIMINATED BY ONE OF THE SCREENING CHECKS.
 C ONCE SCHEDULED, THE MISSION IS REMOVED FROM THE MISSION
 C FILE AND "PIGGYBACKED" ONTO THE AIRCRAFT ATTRIBUTE
 C STRUCTURE; THE MISSION ENTITY IS THUS DESTROYED WHEN
 C SCHEDULED.

C
 C SPECIAL HOME-BASE PROCEDURES:

C IF A MISSION SCHEDULED AT HOME BASE REQUIRES A NEW
 C CREW, A RESTED CREW MUST BE AVAILABLE OR THE MISSION WILL
 C NOT BE SCHEDULED. (THIS IS TO PREVENT "PRE-LOADED" AIR-
 C CRAFT FROM WAITING IN THE NEED-CREW QUEUE WHILE THEIR
 C ASSIGNED MISSION MIGHT HAVE BEEN SCHEDULED ON ANOTHER
 C AIRCRAFT NOT NEEDING A NEW CREW.) IF NO CREWS ARE AVAILABLE,
 C AND IF AN AIRCRAFT HAS A CREW BUT CANNOT FIND A MISSION TO
 C FLY WITHIN REMAINING CREWDAY, THE OLD CREW IS RETURNED TO
 C CREW REST IF IT HAS LESS THAN 25% OF ITS ORIGINAL CREWDAY
 C LEFT. IF AN AIRCRAFT WITH NO CREW ARRIVES AT THE SCHEDULER
 C AND NO CREWS ARE AVAILABLE, NO ATTEMPT IS MADE TO SCHEDULE
 C A MISSION AND THE AIRCRAFT IS SENT TO THE HOLD LOOP.

C IF AN AIRCRAFT IN DEGRADED STATUS (A2-2) CANNOT BE
 C SCHEDULED FOR A MISSION, IT IS GIVEN A 50-50 CHANCE TO
 C GO BACK TO MAINTENANCE, WHERE IT WILL THEN HAVE A FURTHER
 C 50-50 CHANCE TO BE REPAIRED. WITHOUT THIS FEATURE, PMC
 C AIRCRAFT WOULD NEVER BE SCHEDULED IF THE ONLY MISSIONS
 C REMAINING REQUIRED PMC AIRCRAFT, AS IS THE CASE IN MOST
 C FLOWS. (IN REALITY, EVEN DEGRADED AIRCRAFT WOULD BE USED
 C IF REQUIRED IN MAJOR WARTIME MOVES, REGARDLESS OF THE
 C MISSION REQUIREMENTS.)

C
 C VARIABLES:

C	A(40)	REAL	ATRIBS FOR MISSION ENTITY
C	LOC	INT	CURRENT AIRCRAFT LOCATION
C	HOME-BASE	ALTERNATE MISSION SEARCH SEQUENCE	
C	CHECK2	INT	FLAG TO INITIATE ALT SEQ

C	INO	INT	NUMBER IN BASE MISSION FILE
C	MPRI1	INT	PRIORITY OF 1ST MSN AT BASE 1
C	MRDY1	INT	RDY TIME OF 1ST MSN AT BASE 1
C	POSITION LEG CHECK		
C	PSNETA	REAL	TIME OF ARRIVAL AT PICKUP BASE
C	LIMSCH	INT	RISK REQ TO FLY TO PICKUP BASE
C	MBASE	INT	BASE NUMBER OF MSN BEING CHECKED
C	CHKTIM	REAL	CHECK TIME FOR ETACHK
C	DELAY	REAL	DELAY DUE TO FWD BASE TRAFFIC
C	PSNETE	INT	TIME ENROUTE TO PICKUP BASE
C	PSNFLG	INT	IF 1, POSN LEG NEEDED
C	ETAOPN	INT	EARLIEST OPEN ETA AT FWD BASE
C	WXFLG	INT	ENROUTE WX/THREAT INDICATOR
C	MISSION FILE PRIORITY SEARCH		
C	MPRI	INT	MISSION PRIORITY
C	IRANK	INT	FILE RANK OF 1ST MSN WITH MPRI
C	NXTPRI	INT	NEXT HIGHER MSN PRIORITY
C	OLDEST	INT	OLDEST READY TIME THIS PRIORITY
C	OLDNXT	INT	HOLDING FOR OLDEST CHECK
C	LRANK	INT	FILE RANK OF LAST MSN WITH MPRI
C	MISSION SCREENING		
C	TDELAY	INT	TEMP DELAY ACCUMULATOR
C	PTIM	INT	ENROUTE TIME TO PICKUP BASE
C	TFUEL	REAL	FLY TIME UNTIL REFUELING
C	TMSN	INT	ESTIMATED MSN DURATION
C	CDAY	REAL	CREWDAY REMAINING
C	MISSION LEG CHECKS		
C	LEG	INT	MISSION LEG NUMBER
C	ORIG	INT	LEG ORIGINATING BASE
C	ONCGO	INT	LEG ONLOAD CARGO TYPE
C	OFFCGO	INT	LEG OFFLOAD CARGO TYPE
C	DEST	INT	LEG DESTINATION
C	ETMP	INT	EST ELAPSED TIME TO THIS DEST
C	ETAREQ	REAL	INITIAL ETA FOR ETACHK
C	MTIM	INT	EST MSN DURATION FOR HOME CREW CHK

SUBROUTINE SCHED

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COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:  MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NMSET,NTAPE,SS(100),
:  SSL(100),TNEXT,TNOW,XX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
REAL A(40),CHKTIM
INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST,MSNETA,PSNETE,
:  PSNETA,PSNFLG,ETAOPN,ETAFLG,DELAY,MBASE,INO,WXFLG,
:  LIMSCH,TDELAY,ORIG,ONCGO,OFFCGO,DEST,ETMP,ETAREQ
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,6,2*0,1,3,4,3*0,
:  2,2,1,3*0,2,5*0,2,10,4*0,2,10,6,3*0,2,9,4,3*0,
:  10,9,1,3*0,10,2,4*0,10,5*0,10,6,4*0,10,5,4,3*0,
:  6,10,9,1,2*0,6,10,2,3*0,6,10,4*0,6,5*0,6,5,4,3*0,
:  4,3,1,3*0,4,9,2,3*0,4,5,10,3*0,4,5,6,3*0,4,5*0/
DATA ETELST/ 0, 50, 80,150, 90,
:  50, 0, 80,120,150,
:  80, 60, 0, 80,120,
:  150,120, 60, 0, 90,
:  90,150,120, 90, 0/

```

```

DATA BASLST/1,2,3,4,5,
           2,3,4,1,5,
           3,2,4,1,5,
           4,3,2,1,5,
           5,1,2,3,4/
DO 1 MM=1,40
  A(MM)=0
1  CONTINUE
C SCHED TRACE -- XX(97)=2 TO 8
  IF (XX(97).GE.2) THEN
    PRINT *,TNOW,' BEGIN SCHED TRACE, LOC=',ATTRIB(12)
    PRINT *,'   SCHED TRACE LEVEL=',XX(97)
    PRINT *,'   TFLY,TTOT,TFAIL P/E=',ATTRIB(3),ATTRIB(5),
      ATTRIB(6),ATTRIB(7)
    PRINT *,'   GNDTIM,CREWTIM=',(TNOW-ATTRIB(4)),
      (TNOW-ATTRIB(10))
  ENDIF
C NOTE AIRCRAFT LOCATION
  LOC=ATTRIB(12)
C IF HOME BASE AND NON-CREW ACFT AND NO CREWS AVLBL,
C DO NOT TRY TO SCHEDULE
  IF (LOC.EQ.1.AND.ATTRIB(10).EQ.0.AND.NNQ(7).EQ.0) GO TO 99
C DO NOT ATTEMPT TO SCHEDULE NON-MISSION CAPABLE AIRCRAFT
  IF (ATTRIB(2).EQ.3) GO TO 99
  IF (ATTRIB(11).GE.1) GO TO 99
C IF AT BASE 1, CHECK TO SEE IF BASE 2 HAS MISSION WITH HIGHER OR
C EQUAL PRIORITY (USE READY TIME AS TIE-BREAKER). IF SO, SET FLAG
C TO CAUSE SEARCH SEQUENCE 2-3-4-5-1.
  CHECK2=0
  IF (LOC.EQ.1) THEN
C IF NO MSNS AT BASE 1, USE NORMAL SEARCH SEQUENCE
    INQ=NNQ(1)
    IF (INQ.EQ.0) GO TO 5
C FIND PRIORITY/READY TIME OF FIRST MISSION AT BASE 1
    CALL COPY(1,1,A)
    MPRI1=A(5)
    MRDY1=A(1)
    FIRST1=A(1)
C IF NO MSNS AT BASE 2, USE NORMAL SEARCH SEQUENCE
    INQ=NNQ(2)
    IF (INQ.EQ.0) GO TO 5
C IF BASE 2 MSN IS HIGHER PRIORITY (OR OLDER IF PRIORITY
C EQUAL) SET FLAG TO SEARCH BASE 2 FILE FIRST
    CALL COPY(1,2,A)
    IF (MPRI1.GT.A(5)) CHECK2=1
    IF (MPRI1.EQ.A(5).AND.MRDY1.GT.A(1)) CHECK2=1
  ENDIF
C CHECK EACH MSN FILE IN PRESCRIBED ORDER (UNLESS AT BASE 1 AND
C CHECK2=1, WHEN CHECK WILL BE 2-3-4-5-1)
5  ATTRIB(40)=0
  PSNETA=TNOW
  DO 10 I=1,5
    IF (LOC.EQ.1.AND.CHECK2.EQ.1) THEN
      CHECK2=2
      GO TO 10

```

```

ENDIF
C IF AT BASE 1 AND BASE 2 WAS CHECKED FIRST, THE BASE LOOP REPEATED
C TO INCLUDE BASE 1; IF SO AND NO MSN HAS BEEN FOUND, DON'T CHECK
C OTHER FILES AGAIN -- TRY EVERYTHING AGAIN IN AN HOUR.
  IF (CHECK2.EQ.3.AND.1.EQ.2) GO TO 19
  LMSCH=0
  MBASE=BASLST((LOC-1)*5+1)
  IF (XX(97).GE.4) PRINT *, '      MBASE=', MBASE
  CHKTIM=TNOW
  DELAY=0
  PSNETA=TNOW
  PSNETE=0
  PSNFLG=0
  INQ=NNQ(MBASE)
C IF NO MSNS AT THIS BASE, TRY NEXT BASE
  IF (INQ.EQ.0) GO TO 10
C IF BASE BEING CHECKED ISN'T CURRENT LOCATION, CHECK POSITION LEG
  IF (MBASE.NE.LOC) THEN
C IF BASE REQUIRES MAX EFFORT LNDG, NEED FULLY CAPABLE ACFT
    IF (MBASE.GE.4.AND.ATTRIB(2).GE.2) GO TO 10
C FIND ETE TO POSITION BASE; ADD 15 MIN FOR MAIN BASE TAXI TIME,
C THEN FIND ETA AT POSITION BASE
    PSNETE=ETELST((LOC-1)*5+MBASE)
    IF (LOC.LE.2) PSNETE=PSNETE+15
    PSNETA=TNOW+PSNETE
    IF (XX(97).GE.4) PRINT *, '      PSNETA=', PSNETA
C IF POSITION BASE IS 3,4,5, CHECK FOR ETA SLOT (MAX 90 MIN DELAY IF
C LOC=MAIN BASE, 30 MIN DELAY FOR OTHERS)
    IF (MBASE.GE.3) THEN
      CALL ETACHR(MBASE,PSNETA,ETAOPN,ETAFLG)
      IF (XX(97).GE.4) PRINT *,
        :      ETAFLG,ETAOPN=',ETAFLG,ETAOPN
      IF (ETAFLG.EQ.0) GO TO 10
      IF (LOC.LE.2.AND.ETAOPN.GT.(PSNETA+90)) GO TO 10
      IF (LOC.GE.3.AND.ETAOPN.GT.(PSNETA+30)) GO TO 10
C SET DELAY; FIRST OPEN SLOT BECOMES PSNETA
      DELAY=ETAOPN-PSNETA
      IF (DELAY.LT.0) DELAY=0
      PSNETA=ETAOPN
      IF (XX(97).GE.4) PRINT *,
        :      DELAY,PSNETA1=',DELAY,PSNETA
    ENDIF
C CHECK WX AND THREAT FOR POSITION LEG; IF WIFLG 3 OR MORE,
C POSN BASE WX BELOW MINS -- TRY NEXT BASE; IF TERM WX GOOD,
C LMSCH BECOMES 0 (NO THREAT), 1 (LOW THREAT), OR 2 (HIGH
C THREAT); ONLY MSNS REQUIRING AT LEAST THIS RISK CAN BE
C CONSIDERED FOR SCHEDULING
    CHKTIM=PSNETA-ETELST((LOC-1)*5+MBASE)/2
    IF (XX(97).GE.4) PRINT *,
      :      CHKTIM FOR WICHR=',CHKTIM
    CALL WICHR(LOC,MBASE,CHKTIM,WIFLG)
    IF (XX(97).GE.4) PRINT *,
      :      LOC,MBASE,WIFLG=',LOC,MBASE,WIFLG
    IF (WIFLG.GE.3) GO TO 10
    LMSCH=WIFLG

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        PSNFLG=1
        ENDIF
C IF POSITION LEG IS REQUIRED AND FEASIBLE, SET FLAG
        IF (XX(97).GE.4) PRINT *,
            PSNFLG,LIMSCH=' ',PSNFLG,LIMSCH
C CHECK EACH MISSION IN THE FILE
C FIND BEGIN AND END RANK OF EACH BLOCK OF EQUAL-PRIORITY
C MISSION, AND OLDEST MISSION READY TIME WITHIN PRIORITY.
100  CALL COPY (1,MBASE,A)
        MPRI=A(5)
        IRANK=1
        NITPRI=A(5)
        IF (XX(97).GE.5) PRINT *,
            MPRI,IRANK,NITPRI=' ',MPRI,IRANK,NITPRI
C BLOCK DEFINITION LOOP
C FIND BEGINNING AND END OF PRIORITY BLOCK
101  OLDEST=TNOW+1
        DO 102 II=IRANK,INQ
            CALL COPY(II,MBASE,A)
            IF (A(5).GT.MPRI) THEN
                NITPRI=A(5)
                GO TO 103
            ENDIF
            IF (A(5).EQ.MPRI.AND.A(1).LT.OLDEST)
                OLDEST=A(1)
102  CONTINUE
C SET MARKER FOR END OF CURRENT PRIORITY BLOCK
103  IF (NITPRI.EQ.MPRI) THEN
        LRANK=INQ
    ELSE
        LRANK=II-1
    ENDIF
        IF (XX(97).GE.5) PRINT *,
            NITPRI,LRANK,OLDEST=' ',NITPRI,LRANK,OLDEST
C BLOCK SEARCH LOOP
C SEARCH WITHIN PRIORITY BLOCK FOR MISSIONS EQUAL TO
C OLDEST; SIMULTANEOUSLY FIND NEXT OLDEST MISSION IN
C BLOCK.
200  OLDNIT=TNOW+1
201  DO 202,JJ=IRANK,LRANK
            CALL COPY(JJ,MBASE,A)
            IF (A(1).EQ.OLDEST) THEN
                MRANK=JJ
C BEGIN SCREENING CHECKS FOR THIS MISSION
                TDELAY=DELAY
                CHKTIM=PSNETA
                IF (PFLG.EQ.0) THEN
                    PTIM=0
                ELSE
                    PTIM=PSNETA-TNOW
                ENDIF
                IF (XX(97).GE.8) PRINT *,
                    MSN,PRI,RDY,RSK=' ',A(3),A(5),A(1),A(4)
C CHECK FOR TAC MSN AND NON-TAC ACFT
                IF (A(2).EQ.1.AND.ATTRIB(2).GE.2) GO TO 15

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C CHECK FOR MSN NOT JUSTIFYING RISK TO GET TO POSN BASE
  IF (A(4).LT.LIMSch) GO TO 15
C CHECK FOR SUFFICIENT FUEL REMAINING (BASED ON 4200 LB/HR
C BURN RATE AND 50400 LB/12.0 HR FUEL LOAD ON DEPARTURE
C FROM HOME BASE). ESTIMATED MSN TIME (BACK TO HOME BASE
C BASE) IS USED FOR FUEL CHECK; ACFT MUST HAVE FUEL FOR
C EST MSN TIME PLUS POSITION LEG TIME. ACFT BEING SCHED
C AT HOME BASE ARE NOT CHECKED.
  IF (LOC.NE.1) THEN
    TFUEL=600-ATRI(3)
    TMSN=A(38)+PTIM
    IF (TFUEL.LT.TMSN) GO TO 15
  ENDIF
C CHECK FOR SUFFICIENT CREW DAY REMAINING (SAME CRITERIA AS
C FOR FUEL CHECK)
  CDAY=XX(10)-TNOW+ATRI(10)
  IF (XX(97).GE.8) PRINT *,
    CDAYREM,MTIM=',CDAY,(A(38)+PTIM)
  IF (CDAY.LT.(A(38)+PTIM)) THEN
    IF (LOC.NE.1) GO TO 15
C IF AT HOME BASE AND CREW IS NEEDED BUT NONE ARE AVAIL-
C ABLE, TRY NEXT MISSION.
  IF (NNQ(7).EQ.0) GO TO 15
  ENDIF
C CHECK MSN LEG BY LEG FOR WX AND THREAT
  DO 17 LEG=1,4
C IF NEXT DEST = 0, NO MORE LEGS, MSN HAS PASSED CHECKS,
C EXIT SEARCH LOOPS
  IF (A(LEG*3+20).EQ.0) GO TO 20
  ORIG=A(LEG*3+17)
  ONCGO=A(LEG*3+18)
  OFFCGO=A(LEG*3+19)
  DEST=A(LEG*3+20)
  ETMP=A(LEG+32)
  IF (XX(97).GE.8) PRINT *,
    LEG,DEST=',LEG,DEST
C CHECK FOR MHE AVAILABILITY AT ENROUTE BASES REQUIRING
C ONLOAD (ASSUME CARGO CAN BE COMBAT-OFFLOADED IF REQ);
C CHECK FORKLIFTS ONLY (CAN INCLUDE K-LOADERS IN FUTURE
C VERSIONS)
  IF (ONCGO.EQ.2.OR.ONCGO.EQ.3.OR.ONCGO.EQ.6) THEN
    IF (ORIG.EQ.3.AND.XX(73).EQ.0) GO TO 15
    IF (ORIG.EQ.4.AND.XX(74).EQ.0) GO TO 15
  ENDIF
C CHECK FOR ETA SLOT FOR EACH LEG; AIRDROPS DON'T NEED ETA;
C IF EARLIEST AVAIL ETA AT ANY ENROUTE BASE PUSHES DELAY
C OVER LIMIT, TRY NEXT MISSION
  IF (DEST.GE.3.AND.(OFFCGO.LE.4.OR.
    OFFCGO.GE.7)) THEN
    ETAREQ=ETMP+PSNETA+TDELAY
    CALL ETACHK(DEST,ETAREQ,ETAOPN,ETAFLG)
    IF (XX(97).GE.8) PRINT *,
      ETAREQ,ETAOPN=',ETAREQ,ETAOPN
    IF (ETAFLG.EQ.0) GO TO 15
    TDELAY=TDELAY+ETAOPN-ETAREQ

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        IF (LOC.LE.2.AND.TDELAY.GT.90) GO TO 15
        IF (LOC.GE.3.AND.TDELAY.GT.30) GO TO 15
    ENDIF
C COMPUTE CHKTIM FOR WX AND THREAT CHECK -- CHECK CONDITIONS
C BASED ON TIME TO MIDPOINT OF CURRENT LEG; THREAT AND WX WILL
C REFLECT CURRENT CONDITIONS (ASSUMED TO BE VALID FOR THE NEXT
C SEVERAL HOURS); ESCORT EVALUATION WILL REFLECT PLANNED
C AVAILABILITY AT CHKTIM; IF WX BAD FOR LEG OR IF MSN DOESN'T
C ALLOW RISK REQUIRED FOR LEG, TRY NEXT MSN
    CHKTIM=TNOW+TDELAY+ETMP-
        (ETELST((ORIG-1)*5+DEST)/2)
    CALL WCHK(ORIG,DEST,CHKTIM,WXFLG)
    IF (XX(97).GE.8) PRINT *,
        WXFLG=',WXFLG
    IF (WXFLG.GT.A(4)) GO TO 15
17    CONTINUE
    GO TO 20
ENDIF
C RESUME SEARCH OF MISSION FILE IF MISSION IS REJECTED
15    IF (A(1).GT.OLDEST.AND.A(1).LT.OLDNXT) OLDNXT=A(1)
202    CONTINUE
C IF MORE MISSION IN CURRENT BLOCK, RE-ENTER BLOCK
C SEARCH LOOP
    IF (OLDNXT.LE.TNOW) THEN
        OLDEST=OLDNXT
        GO TO 200
    ENDIF
C IF ANOTHER PRIORITY BLOCK, RE-ENTER BLOCK DEFINITION
C LOOP
    IF (NXPRI.GT.MPRI) THEN
        MPRI=NXPRI
        IRANK=LRANK+1
        GO TO 101
    ENDIF
C IF NO MORE PRIORITY BLOCKS (END OF CURRENT FILE) GO TO
C NEXT BASE FILE
10    CONTINUE
C IF THROUGH BASE LOOP AND MSN NOT FOUND, AND IF BASE 2 WAS
C CHECKED BEFORE BASE 1 BECAUSE OF AN OLDER MISSION, RESTART
C THE LOOP TO CHECK BASE 1
10    IF (LOC.EQ.1) THEN
        IF (CHECK2.EQ.2) THEN
            CHECK2=3
            GO TO 3
        ENDIF
    ENDIF
C IF NO MSNS FOUND AND NOT AT BASE 1, GENERATE DEADHEAD LEG
C TO HOME BASE; IF AT BASE 1, SET SWITCH FOR 60-MINUTE DELAY
C LEG.
90    IF (LOC.GE.2) THEN
        ATRIB(17)=0
        CALL DEDNED(LOC)
        IF (XX(97).GE.2) PRINT *, '    DEDNED CALLED'
        IF (ATRIB(16).EQ.1) CALL MTRACE(3)
        IF (ATRIB(16).EQ.1) CALL MTRACE(50)

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        RETURN
    ENDIF
C IF AIRCRAFT HAS CREW BUT NO MISSION COULD BE FOUND,
C RETURN CREW TO CREW REST IF LESS THAN 25% OF ORIGINAL
C CREWDAY REMAINING.
    CDAY=XX(10)-TNOW+ATRI(10)
    IF (CDAY.GT.(.75*XX(10))) THEN
        IF (ATRI(10).NE.0) THEN
            CALL ENTER(6,ATRI)
            ATRI(10)=0
        ENDIF
    ENDIF
C IF AIRCRAFT IS IN DEGRADED STATUS AND MISSION COULD
C NOT BE FOUND, 50% CHANCE TO RETURN AIRCRAFT TO MAIN-
C TENANCE FOR POSSIBLE REPAIR AND UPGRADE TO FMC STATUS.
    IF (ATRI(2).GE.2) THEN
        X1=UNFRM(0.,100.,1)
        IF (X1.GE.50) THEN
            ATRI(16)=100
            ATRI(37)=88987
            ATRI(15)=1
            RETURN
        ENDIF
    ENDIF
    ATRI(16)=0
    IF (XX(97).GE.2) PRINT *, '          DEDHED HOLD'
    RETURN
C IF AT MAIN BASE AND MSN IS GOOD, CHECK FOR CREW CHANGE
C BASED ON MSN DURATION; SET FLAG IF NEW CREW NEEDED;
C ALL NON-CREW ACFT REQUIRE CREW (ATRI(10)=0).
20  IF (LOC.EQ.1) THEN
        ATRI(16)=0
        IF (ATRI(10).EQ.0) THEN
            ATRI(16)=1
            IF (XX(98).GE.1) PRINT *, 'NON-CREW ACFT SCHED'
            GO TO 1000
        ENDIF
        CDAY=XX(10)-TNOW+ATRI(10)
        MTIM=A(36)+PTIM+TDELAY
        IF (CDAY.LT.MTIM) ATRI(16)=1
        IF (XX(97).GE.3) THEN
            IF (ATRI(16).EQ.0) PRINT *, '          CREW OK, CDAYREM=',
            :          CDAY
            IF (ATRI(16).EQ.1) PRINT *, '          CREW NEEDED,'
            :          ' CDAY,MTIM=',CDAY,MTIM
        ENDIF
    ENDIF
C "PIGGYBACK" MSN ATRIS ONTO ACFT
1000 CALL SCHSET(A,TDELAY,PSNETA,PSNETE,PSNFLG,MBASE,MFRANK,LOC)
    CALL MTRACE(3)
    CALL MTRACE(50)
    RETURN
END

```



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SUBROUTINE SCHSET(A,TDELAY,ETAP,ETEP,PFLG,MBASE,MRANK,LOC)
C CALLED BY SCHED TO PIGGYBACK MISSION ATRIBS ONTO ACFT. SCHSET
C ALSO PERFORMS HOUSEKEEPING ROUTINE ON ETA FILES BY ELIMINATING
C ALL ETAS OLDER THAN TNOW MINUS ONE HOUR (TIMES MUST BE RETAINED
C FOR PROPER ETA CHECKING, WHICH NEEDS PREVIOUS ETAS FOR PLUS/MINUS
C ONE HOUR OF PROPOSED ARRIVAL). THE ETA FILES ARE THEN COMPRESSED
C AND FILLED OUT WITH ZEROS, SO THAT THE NEXT ETA ENTERED WILL BE
C AT THE END OF THE NON-ZERO ENTRIES FOR A PARTICULAR BASE.
C THE MISSION ENTITIES ARE DESTROYED BY DEFAULT, SINCE THEY ARE
C NOT REENTERED AFTER THEY HAVE BEEN REMOVED FROM THE MISSION
C FILES.

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C
C VARIABLES:
C      ETALST(150)   INT    FWD BASE ETA FILE
C      A(40)         REAL   MISSION ATRIBS
C      TDELAY        INT    MISSION DELAY
C      ETAP          INT    ETA AT PICKUP BASE
C      ETEP          INT    ETE TO PICKUP BASE
C      PFLG          INT    IF 1, POSITION LEG REQ
C      MBASE         INT    MISSION PICKUP BASE
C      MRANK         INT    MISSION FILE RANK
C      LOC           INT    CURRENT ACFT LOCATION
C      EPTR          INT    ETALST POINTER
C      MSNETA        INT    SCHED MSN BASES AND ETAS
C      ETMP          INT    TEMP ETALST XFER VARIABLE
C

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COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:  MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),SSL(100),
:  TNEXT,TNOW,IX(100)
COMMON/UCOM2/ ETALST(150)
REAL A(40)
INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST,MSNETA(40),ETMP,
:  ETAP,ETEP,TDELAY,PFLG,EPTR
IF (IX(20).EQ.0) THEN
  DO 1 K=1,150
    ETALST(K)=0
1  CONTINUE
  IX(20)=1
ENDIF
DO 2 K=1,10
  MSNETA(K)=0
2  CONTINUE
T=TNOW+TDELAY
DO 3 K=1,4
  IF (A(K*3+20).GE.1.AND.A(K*3+20).LE.5) THEN
    MSNETA((K+1)*2-1)=A(K*3+20)
    MSNETA((K+1)*2)=A(K*3+20)+T
  ENDIF
3  CONTINUE
IF (PFLG.EQ.1) THEN
  MSNETA(1)=MBASE
  MSNETA(2)=ETAP
ELSE
  MSNETA(1)=1
ENDIF
ENDIF

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DO 23 I=1,9,2
  IF (MSNETA(I).EQ.0) GO TO 50
  IF (MSNETA(I).LE.2) GO TO 23
  EPTR=(MSNETA(I)-3)*50
  K=1
DO 24 J=1,50
  ETMP=ETALST(EPTR+J)
  IF (ETMP.GT.TNOW) THEN
    ETALST(EPTR+K)=ETMP
    K=K+1
    IF (XX(97).GE.9) PRINT *,
      '      ' ETALST ',K-1,',' ETALST(EPTR+K-1)
  ENDIF
  IF (ETMP.EQ.0) GO TO 25
24 CONTINUE
C IF ETA FILE FULL (ALL ETAS NEEDED) PRINT MSG AND GO TO NEXT
C LEG, OTHERWISE FILE NEW ETA. IF FILE FULL (IT SHOULDN'T BE)
C FLY THE MISSION AS SCHEDULED.
  IF (K.EQ.51) PRINT *, 'ETA FILE BASE ',LOC,' FULL AT ',
    TNOW
  IF (K.EQ.51) GO TO 23
25 ETALST(EPTR+K)=MSNETA(I+1)
  IF (XX(97).GE.9) PRINT *,
    '      ' NEW ETA=',ETALST(EPTR+K),' PSN=',K
C FILL THE REST OF THE ETA FILE FOR LOC WITH ZEROS
DO 26 L=K+1,50
  ETALST(EPTR+L)=0
26 CONTINUE
23 CONTINUE
C PIGGYBACK MSN ATRIES ONTO ACFT
C IF POSITION LEG NEEDED, PUT ITS DATA IN CURRENT LEG SLOTS
C (A12-15), THEN PLACE MISSION LEGS IN SEQUENTIAL LEG SLOTS
C (A20-32).
50 IF (PFLG.EQ.1) THEN
  ATRIB(12)=LOC
  ATRIB(13)=0
  ATRIB(14)=0
  ATRIB(15)=MBASE
  DO 51 I=20,32
    ATRIB(I)=A(I)
51 CONTINUE
  ENDIF
C IF POSITION LEG NOT NEEDED, PUT FIRST MISSION LEG DATA IN
C CURRENT LEG SLOTS AND FOLLOWING LEG DATA IN SEQUENTIAL SLOTS.
C FILL LAST LEG SLOTS WITH ZEROS SINCE MISSION DATA HAS BEEN
C SHIFTED DOWN ONE LEG.
  IF (PFLG.EQ.0) THEN
    ATRIB(12)=MBASE
    ATRIB(13)=A(21)
    ATRIB(14)=A(22)
    ATRIB(15)=A(23)
    DO 52 I=23,32
      ATRIB(I-3)=A(I)
52 CONTINUE
    DO 53 I=30,32

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      ATRIB(1)=0
53      CONTINUE
      ENDIF
C CLEANUP (NOTE THAT A17=TDELAY -- ALL DELAY IS TAKEN AT
C ORIGINATING BASE; PLANNED DELAYS ENROUTE ARE NOT ALLOWED
C -- YET.)
      ATRIB(11)=0
      ATRIB(18)=1
      ATRIB(17)=TDELAY
C ATRIBS 36-39 WILL CARRY ORIGINAL MISSION ATRIBS 1-5:
C ORIG READY TIME, TYPE ACFT REQUIRED, MISSION NO,
C RISK LEVEL, AND PRIORITY
      DO 60 I=1,5
          ATRIB(34+I)=A(I)
60      CONTINUE
C DESTROY THE MISSION ENTITY
      CALL RMOVE(MRANK,MBASE,A)
      RETURN
      END

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SUBROUTINE DEDHED(LOC)
C WHEN AN AIRCRAFT FINISHES A MISSION AT OTHER THAN HOME
C BASE AND A NEW MISSION CANNOT BE FOUND, THE AIRCRAFT
C MUST RETURN EMPTY TO HOME BASE. AIRCRAFT ARE NOT ALLOWED
C TO REMAIN AT ENROUTE BASES WITH NO MISSION. IF AT BASE 5,
C THE AIRCRAFT MUST RETURN HOME REGARDLESS OF THREAT, SINCE
C THIS TYPE OF BASE IS CONSIDERED UNSAFE. IF AT BASE 2, 3,
C OR 4, PROTECTION IS ASSUMED TO BE AVAILABLE AND THE AIRCRAFT
C CAN REMAIN THERE TEMPORARILY. SCHED WILL ATTEMPT TO
C RESCHEDULE THESE AIRCRAFT EVERY 60 MINUTES UNTIL THEY
C EITHER FIND A MISSION OR CAN RETURN HOME. IF AT BASE 3
C OR 4, HOWEVER, AND IF AN INBOUND AIRCRAFT IS HOLDING
C FOR A SLOT AT THAT BASE, THE EMPTY AIRCRAFT MUST LEAVE.
C DEDHED IS ALSO CALLED BY THE ENGINE-START PROCEDURE WHEN
C ANY AIRCRAFT NOT AT HOME BASE MUST MAKE AN UNSCHEDULED TRIP
C TO HOME BASE (ABORTING). IN THIS CASE, DEDHED IS USED TO
C MAKE A LAST-MINUTE WEATHER/THREAT CHECK FOR THE NEWLY-
C ABORTING AIRCRAFT. IF THREAT/WEATHER ARE NOT ACCEPTABLE
C (AND IF FORCE-OUT CONDITIONS DO NOT APPLY) THE AIRCRAFT MAY
C TEMPORARILY REMAIN AT ITS CURRENT BASE ON A "DEPARTURE HOLD".
C THE AIRCRAFT WILL RETURN TO RESTRT (AND THUS TO DEDHED) EVERY
C 60 MINUTES UNTIL CONDITIONS ALLOW IT TO DEPART FOR HOME.
C ("FORCE-OUT" RULES APPLY TO BOTH ABORTS AND NON-ABORTS).
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),
: TNEXT,TNOW,XX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
INTEGER ZONLST,ETELST,BASLST,ETEHOM,WIFLG
C CHECK FOR "FORCE-OUT" CONDITIONS
IF (LOC.EQ.3.AND.(NNQ(8).GT.0.OR.NNQ(9).GT.0)) GO TO 20
IF (LOC.EQ.4.AND.(NNQ(15).GT.0.OR.NNQ(16).GT.0)) GO TO 20
IF (LOC.EQ.5) GO TO 20
C IF RISK PRIORITY IS 2, GO REGARDLESS
IF (ATRI(40).EQ.2) GO TO 20
CHKTIM=TNOW
CALL WCHK(LOC,1,CHKTIM,WIFLG)
IF (WIFLG.GT.ATRI(4)) THEN
    ATRIB(16)=0
    RETURN
ENDIF
20 ATRIB(40)=2
    ATRIB(16)=1
C IF ALREADY LOADED (AS FOR SOME ABORTS) DON'T CHANGE ATRIBS
IF (ATRI(11).GE.1) GO TO 99
C IF ALREADY DEADHEADING (MSN = 80000-89999) DON'T CHANGE
IF (ATRI(37).GE.80000.AND.ATRI(37).LE.89999) GO TO 99
C IF COMING DIRECTLY FROM SCHEDULER (NO MSN AVAIL) SET UP
C MISSION ATTRIBUTES FOR DEADHEAD LEG TO HOME BASE
    ATRIB(12)=LOC
    ATRIB(13)=0
    ATRIB(14)=0
    ATRIB(15)=1
    DO 21 I=16,39
        ATRIB(I)=0
21 CONTINUE
    ATRIB(37)=80000+LOC*1000+XX(30)*100+XX(28)
99 RETURN
END

```

```

C ETACHK -- CHECKS FOR NON-CONFLICTING ARRIVAL TIME AT A BASE
C
C INPUT --      DEST      DESTINATION BASE CODE
C              ETAREQ     INITIAL PROPOSED ETA
C              ETALST     FILE OF PREVIOUSLY SCHEDULED ETAS
C              MOGLST     MAX NUMBER OF ARRIVALS PER HOUR LOOKUP TABLE
C OUTPUT --     ETAOPN     FIRST OPEN ARRIVAL TIME SLOT
C              ETAFLG     0 IF NO SLOTS WITHIN 4 HOURS OF ETAREQ; ELSE 1
C INTERNAL --   EPTR      POINTER TO ETALST
C              NETA       NUMBER OF ETAS WITHIN 1-HR WINDOW BEING CHECKED
C
C 1. SET ETAFLG TO 1.
C 2. CREATE EPTR (POINTS TO BEGINNING OF PROPER 50-ENTRY VECTOR).
C 3. SET ETAOPN=ETAREQ (KEEP ETAREQ FOR REFERENCE).
C 4. CHECK EACH 1-HOUR WINDOW FROM (ETAOPN MINUS 1 HR) TO (ETAOPN PLUS
C    1 HR USING 5-MINUTE INCREMENTS BETWEEN WINDOWS:
C    A. INITIALIZE NETA TO ZERO.
C    B. CHECK EACH OF 50 ENTRIES IN ETALST VECTOR (SEE NOTES):
C       IF IN WINDOW, NETA=NETA+1
C    C. IF NETA EXCEEDS MAX NO OF ARRIVALS PER HOUR, THIS WINDOW
C       IS BAD; SINCE ALL WINDOWS MUST BE GOOD FOR AN
C       ARRIVAL TIME SLOT TO BE ACCEPTABLE, THIS VALUE
C       OF ETAOPN IS NOT VALID AND A NEW ETAOPN MUST BE
C       CHECKED; INCREMENT ETAOPN BY NUMBER OF WINDOWS
C       CHECKED TIMES 5 MINUTES:
C       IF NEW ETAOPN IS MORE THAN 4 HRS FROM ETAREQ, SET
C       ETAFLG=0 AND RETURN (NO SLOTS AVAILABLE).
C       IF NEW ETAOPN IS WITHIN 4 HRS, REPEAT (4) WITH NEW
C       ETAOPN.
C    D. IF THIS WINDOW IS GOOD, CHECK NEXT WINDOW.
C 5. WHEN ALL WINDOWS FOR A SPECIFIC VALUE OF ETAOPN ARE GOOD, THAT
C    VALUE OF ETAOPN IS A VALID ARRIVAL TIME; RETURN.
C
C NOTES: WINDOWS ARE ONLY CHECKED IN 5-MINUTE INCREMENTS TO PREVENT
C        EXCESS TIME REQUIREMENTS FOR SHORTER INTERVALS;
C        5 MINUTES WAS SHOWN ON TEST RUNS TO BE
C        SATISFACTORY.
C
C        THE CONCEPT OF MAX NUMBER OF ARRIVALS PER HOUR CORRESPONDS
C        TO THE CONCEPT OF MAX NO OF ACFT ON THE GROUND
C        (MOG); IN MOST CASES, THE TWO NUMBERS WILL BE
C        THE SAME IF THE AVERAGE GROUND TIME DOES NOT
C        DIFFER TOO GREATLY FROM AN HOUR. THIS MODEL
C        ALLOWS THE USER TO SET "HOURLY FLOW RATES"
C        WHICH ARE SEPARATE FROM MOG LIMITS AND WHICH
C        WILL BE USED BY THE SCHEDULER TO LIMIT ARRIVALS
C        AT AFFECTED BASES.
C
C        THE PRIMARY USE OF THIS CONCEPT IS TO AVOID LARGE HOLDING
C        QUEUES AT FORWARD BASES, PARTICULARLY IN WARTIME.
C
C        THE ENTIRE 50-ENTRY VECTOR FOR A PARTICULAR BASE IS NOT
C        ACTUALLY CHECKED FOR EACH WINDOW; SUBROUTINE
C        SETSCH INCLUDES A HOUSEKEEPING ROUTINE WHICH
C        INSURES THAT ONLY CURRENT ENTRIES ARE IN THE
C        VECTOR. THESE ENTRIES ARE FURTHER STORED CON-
C        TIGUOUSLY IN THE FIRST PART OF THE VECTOR;
C        THE END OF THE VALID ENTRIES IS MARKED WITH A

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C ZERO; ACCORDINGLY, WHEN A SEQUENTIAL SEARCH OF
 C THE VECTOR ENCOUNTERS A ZERO, THERE ARE NO
 C FURTHER ENTRIES OF INTEREST IN THE VECTOR.
 C ETA FILES ARE NOT MAINTAINED FOR MAIN BASES.
 C

```

SUBROUTINE ETACHK(DEST,ETAREQ,ETAOPN,ETAFLG)
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:   MSTOP,NCLNR,NCRDR,NPRMT,NMRUN,NNSET,NTAPE,SS(100),SSL(100),
:   TNEXT,TNOW,XX(100)
COMMON/UCOM2/ETALST(150)
INTEGER ETALST,ZONLST,ETELST,BASLST,MOGLST(5),MSNETA,
:   ETAREQ,ETAOPN,EPTR,NETA,ETAFLG,DEST
DATA MOGLST/99,99,8,2,2/
IF (XX(20).EQ.0) THEN
  DO 1 K=1,150
    ETALST(K)=0
1    CONTINUE
    XX(20)=1
  ENDIF
C SET ETAFLG TO 1; CREATE EPTR; INITIALIZE ETAOPN=ETAREQ
  ETAFLG=1
  EPTR=(DEST-3)*50
  ETAOPN=ETAREQ
C MAIN LOOP FOR "WINDOW CHECK" OF A SPECIFIC VALUE OF ETAOPN
5    DO 10 I=ETAOPN,ETAOPN+80,5
C INITIALIZE NETA=0 FOR EACH WINDOW
      NETA=0
C FOR EACH WINDOW, CHECK 50-ENTRY ETALST VECTOR AND INCR NETA IF
C REQ.
      DO 11 J=1,50
        IF (ETALST(EPTR+J).GE.(I-50).AND.
          :   ETALST(EPTR+J).LE.I) THEN
          NETA=NETA+1
          IF (XX(97).GE.9) PRINT *, '      NETA=',NETA
        ENDIF
        IF (NETA.GE.XX(85+DEST)) THEN
          ETAOPN=I+5
C IF NEW ETAOPN NOT WITHIN 4 HRS, GIVE UP
          IF (ETAOPN.GT.(ETAREQ+240)) THEN
            ETAFLG=0
            ETAOPN=0
            RETURN
          ENDIF
C IF NEW VALUE OF ETAOPN WITHIN 4 HRS, RESTART MAIN LOOP WITH NEW
C ETAOPN.
          GO TO 5
        ENDIF
C IF NEXT ENTRY IN ETALST VECTOR IS ZERO, NO MORE ENTRIES OF
C INTEREST; BEGIN CHECK OF NEXT WINDOW
        IF (XX(97).GE.9) PRINT *,
          :   '      ETACHK LAST ENTRY NR ',J,'=',ETALST(EPTR+J)
        IF (ETALST(EPTR+J+1).EQ.0) GO TO 10
11    CONTINUE
10    CONTINUE
      RETURN
    END
  
```

AD-A115 692

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOO--ETC F/G 15/5
AN ALASKAN THEATER AIRLIFT MODEL.(U)

FEB 82 D S BOWERS

AFIT/OST/OS/82M-4

UNCLASSIFIED

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3 3
2 2



END

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SUBROUTINE WX(J)
C DATA IS LOADED TO REPRESENT THIS MATRIX (FOR SEASON 1)
C
C      WX NOW = 1 11 111  PROBABILITIES ARE IN TENTHS.  FOR DATA
C      1 5 4 4  STATEMENT, MAKE ONE VECTOR WITH FIRST
C      11 3 4 5  COLUMN LISTED FIRST, THEN SECOND COLUMN,
C      111 2 2 1  THEN THIRD COLUMN, THEN REPEAT PATTERN
C      FOR NEXT SEASON MATRICES, ETC.
C FOR RETRIEVAL, POINTER IS (SEASON-1)*9+(IWZ-1)*3+1
C )))THIS FEATURE OF THE MODEL IS AWAITING WEATHER DATA FROM
C AIR WEATHER SERVICE. IT WILL EVENTUALLY HAVE TEN SEPARATE
C MATRICES, ONE FOR EACH ZONE. THE CURRENT MATRIX IS USED
C FOR ALL ZONES AND REPRESENTS A ROUGH APPROXIMATION OF
C WEATHER CONDITIONS IN SOUTH-CENTRAL ALASKA. TO EXPAND
C FOR NEW ZONES, USE COMPUTED GO TO (1 THRU 10) OR USE
C LARGE DATA MATRIX WITH INDICES FOR 10 BASES.
C
C VARIABLES:
C      W          INT          MARKOV PROBABILITY MATRIX
C      SEASON      INT          SEASON
C      TDAY        INT          TIME OF DAY
C      N1, N2      INT          TEMP PROB VRBLs
C      IWZ         INT          WEATHER CODE
C      X           REAL         RANDOM VARIATE
C
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:  MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),
:  SSL(100),TNEXT,TNOW,IX(100)
INTEGER SEASON,TDAY,IWZ,W(36)
DATA W/5,3,2,4,4,2,4,5,1,
:  3,5,2,3,4,3,2,6,2,
:  5,3,2,6,2,2,3,5,2,
:  3,5,2,3,4,3,2,6,2/
SEASON=IX(31)
TDAY=IX(26)
X=UNFRM(1.,10.,1)
C FOG CHECK -- IF WX IS CLEAR IN FALL OR WINTER, FOG IS POSSIBLE.
C FOG CAN ONLY FORM DURING EARLY MORNING HOURS (TDAY = 00 TO 12).
C IF FOG HAS FORMED DURING THE 00-06 PERIOD, IT MAY "FORM AGAIN"
C FOR THE 06-12 PERIOD. IF FOG ALREADY EXISTS AND DOES NOT "FORM
C AGAIN", IT BURNS OFF (MOST LIKELY TO CLEAR, BUT POSSIBLY TO
C MEDIUM OR EVEN LOW OVERCAST).
IF (SEASON.EQ.2.OR.SEASON.EQ.3) THEN
  IF (IWZ.EQ.1.OR.IWZ.EQ.4) THEN
    IF (TDAY.GE.00.AND.TDAY.LT.12) THEN
      IF (X.LE.4) THEN
        IWZ=4
        GO TO 10
      ENDIF
    ENDIF
  ENDIF
ENDIF
IF (IWZ.EQ.4) THEN
  IF (X.LE.6) IWZ=1
  IF (X.GT.6.AND.X.LE.9) IWZ=2
  IF (X.GT.9) IWZ=3

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        GO TO 10
    ENDIF
C REGULAR WX ADJUSTMENT ROUTINE
    N1=W((SEASON-1)*9+(IWX-1)*3+1)
    N2=N1+W((SEASON-1)*9+(IWX-1)*3+1)
    IF (X.LE.N1) THEN
        IWX=1
        GO TO 10
    ENDIF
    IF (X.LE.N2) THEN
        IWX=2
        GO TO 10
    ENDIF
    IWX=3
    IF (XX(99).EQ.3) PRINT 1000,TNOW,TDAY*100,J,IWX
10      XX(40+J)=IWX
    RETURN
1000   FORMAT (1X,F7.1,15,' WX IN ZONE ',I2,' = ',I1)
    END

```

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C WCHCK -- CHECKS WX AND THREAT FOR A SPECIFIC LEG
C
C INPUT --      ORIG      LEG START BASE CODE
C              DEST      LEG END BASE CODE
C              CHKTIM     TIME FOR FTRCHK CALL
C              ZONLST     ZONE LOOKUP TABLE
C              ALLWX      XX(81-85) -- BASE INSTRUMENT APP CODES
C              THRT       XX(50-59) -- ZONE THREAT CODES
C              WX         XX(40-49) -- ZONE WEATHER CODES
C OUTPUT --      WIFLG     0 = NO TERM WX OR THREAT PROBLEMS
C                   1 = TERM WX OK, LOW THREAT ENROUTE
C                   2 = TERM WX OK, HIGH THREAT
C                   3 = TERM WX BELOW MINS, NO THREAT
C                   4 = TERM WX BAD AND LOW THREAT
C                   5 = TERM WX BAD AND HIGH THREAT
C INTERNAL --    ZPTR      ZONLST POINTER
C              ZONE       ZONE BEING CHECKED
C CALLS --      FTRCHK     EVALUATES ESCORT AVAILABILITY AT CHKTIM
C
C 1.  CREATE POINTER FOR ZONLST.
C 2.  LOOP THROUGH APPROPRIATE VECTOR IN ZONLST.  VECTOR CONTAINS
C      SIX ENTRIES; ZONES ARE LISTED IN SEQUENCE FROM ORIG TO
C      DEST (UP 5 ZONES MAX); AFTER LAST ZONE, VECTOR IS FILLED
C      OUT WITH ZEROS (ENTRY 6 IS ALWAYS ZERO).
C 3.  FOR EACH ZONE IN VECTOR:
C      A.  SET CURRENT WEATHER AND THREAT CODES.
C          THREAT INDEX AND TERM WX INDEX = 0
C      B.  IF THREAT EXISTS, THEN CALL FTRCHK FOR ESCORT AVAIL
C          IF WX LOW, NO ESCORT, HIGH THREAT = 2
C          IF WX CLR, NO ESCORT, LOW THREAT = 1
C          IF WX LOW, WITH ESCORT, LOW THREAT = 1
C      C.  IF NEXT ENTRY IN VECTOR IS ZERO (CURRENT ZONE IS DEST
C          ZONE) THEN
C          IF WX IS FOG AND DEST HAS NO PREC APPROACH = 3
C          IF WX IS LOW CLOUDS AND DEST HAS NO APPROACH = 3
C          WIFLG = THREAT INDEX PLUS TERM WX INDEX
C      D.  IF THIS WAS NOT DEST ZONE, REPEAT (3) FOR NEXT ZONE
C          HIGHEST THREAT INDEX IS MAINTAINED
C
C NOTES: IF THERE IS NO THREAT IN A ZONE, THE MISSION IS ASSUMED TO
C         BE ABLE TO TRANSIT THAT ZONE REGARDLESS OF THE WEATHER.
C         IF THREAT EXISTS, THIS ZONE MUST BE TRANSITED LOW-LEVEL IF
C         POSSIBLE MIDDLE CLOUDS PROVIDE IDEAL COVER AND NO ESCORT
C         IS REQUIRED. CLEAR WEATHER LEAVES SOME CHANCE OF DETEC-
C         TION BY FIGHTERS, SO ESCORT IS REQUIRED. FOG OR LOW
C         CLOUDS FORCE FLIGHT AT HIGHER ALTITUDES, SO PROBABILITY
C         IF DETECTION IS HIGH AND ESCORT IS MANDATORY.
C         WEATHER IS ASSUMED TO BE UNIFORM THROUGHOUT A ZONE.
C         PRECISION APPROACHES ARE ASSUMED TO ALLOW LANDINGS IN FOG.
C         A BASE WITH NO APPROACHES IS USABLE ONLY IF WEATHER IS MIDDLE
C         CLOUDS OR BETTER (CORRESPONDS TO VFR CONDITIONS).
C         PREPLANNED HOLDING FOR WEATHER AT ANY BASE IS NOT ALLOWED.
C         WEATHER FORECASTING IS NOT ATTEMPTED -- SCHEDULING AND WEATHER
C         CHECKING ASSUMES EXISTING CONDITIONS WILL HOLD FOR THE

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C          NEXT SEVERAL HOURS (THIS IS REALISTIC WHEN OPERATING
C          IN A "LINE-OF-SIGHT" SCHEDULING MODE.)
C
SUBROUTINE WCHK(ORIG,DEST,CHKTIM,WXFLG)
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
:  MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),
:  TNEXT,TNOW,XX(100)
REAL A,CHKTIM
INTEGER ORIG,DEST,ESCTMP,WXFLG,ALLWX,THRT,ZPTR,ZONE,
:  FTRFLG,WX,ZONLST(150)
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,6,2*0,1,3,4,3*0,
:  2,2,1,3*0,2,5*0,2,10,4*0,2,10,6,3*0,2,9,4,3*0,
:  10,9,1,3*0,10,2,4*0,10,5*0,10,6,4*0,10,5,4,3*0,
:  6,10,9,1,2*0,6,10,2,3*0,6,10,4*0,6,5*0,6,5,4,3*0,
:  4,3,1,3*0,4,9,2,3*0,4,5,10,3*0,4,5,6,3*0,4,5*0/
WXFLG=0
C SET ALLWX AND ZPTR
ALLWX=XX(DEST+88)
ZPTR=(ORIG-1)*30+(DEST-1)*6
C LOOP THROUGH ZONES
DO 10 I=1,6
C FIND NEXT ZONE, SET WEATHER AND THREAT
ZONE=ZONLST(ZPTR+I)
WX=XX(ZONE+40)
THRT=XX(ZONE+50)
C CHECK FOR THREAT/WEATHER/ESCORT
IF (WX.NE.2.AND.THRT.EQ.1) THEN
CALL FTRCHK(ZONE,CHKTIM,FTRFLG)
IF (WXFLG.EQ.0) THEN
IF (WX.EQ.1.AND.FTRFLG.EQ.0) WXFLG=1
IF (WX.GE.3.AND.FTRFLG.EQ.1) WXFLG=1
IF (WX.GE.3.AND.FTRFLG.EQ.0) WXFLG=2
ENDIF
IF (WXFLG.EQ.1) THEN
IF (WX.GE.3.AND.FTRFLG.EQ.0) WXFLG=2
ENDIF
ENDIF
C DESTINATION WX CHECK: IF THIS IS NOT THE LAST ZONE (NEXT VECTOR
C ENTRY IS NOT ZERO), BYPASS AND CHECK NEXT ZONE.
IF (ZONLST(ZPTR+I+1).EQ.0) THEN
C IF FOG, NEED PRECISION APPROACH
IF (WX.EQ.4) THEN
IF (ALLWX.NE.2) GO TO 99
ENDIF
C IF LOW CLOUDS, NEED ANY APPROACH
IF (WX.EQ.3) THEN
IF (ALLWX.EQ.0) GO TO 99
ENDIF
C IF DEST APPROACH SUITS DEST WX, LEG IS "SCHEDULABLE"
RETURN
ENDIF
10 CONTINUE
C EXIT BLOCK FOR TERM WX
99 WXFLG=WXFLG+3
RETURN
END

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      SUBROUTINE FTRCHK(ZONE,TCHK,FTRFLG)
C GIVEN INPUT OF ZONE AND TIME, RETURNS FTRFLG=0 IF NO ESCORT
C OR FTRFLG=1 IF ESCORT AVAILABLE. ASSUMES ESCORT AVAILABILITY
C WILL BE SIMILAR FROM DAY TO DAY. DATA IS REQUIRED FOR EACH
C HOUR AND EACH ZONE FOR ONE DAY (TOTAL 240); 0 = NO ESCORT,
C 1 = ESCORT AVAILABLE. IF XX(36)=0, FTRCHK WILL BE 0 FOR ALL
C CHECKS; IF XX(36)=1, ALL CHECKS WILL RETURN 1; IF XX(36)=2,
C DATA ARRAY WILL BE CONSULTED AND APPROPRIATE VALUE RETURNED.
      COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
      : MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),
      : SSL(100),TNEXT,TNOW,XX(100)
      INTEGER FTRFLG,ZONE,HOUR,FTR(240)
C EXPAND THIS DATA STATEMENT TO USE VARYING ESCORT FEATURE:
C FILL IN ZONE 1 (ALL 24 HOURS), THEN ZONE 2 (24 HOURS), ETC.
      DATA FTR/240*1/
      IF (XX(36).EQ.0) THEN
        FTRFLG=0
        RETURN
      ENDIF
      IF (XX(36).EQ.1) THEN
        FTRFLG=1
        RETURN
      ENDIF
      HOUR=(AMOD(TCHK,1440.)*24)+XX(29)
      IF (HOUR.GT.24) HOUR=HOUR-24
      IPTR=((ZONE-1)*24)
      IF (FTR(IPTR+HOUR).EQ.0) THEN
        FTRFLG=0
      ELSE
        FTRFLG=1
      ENDIF
      RETURN
      END

```

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      SUBROUTINE THREAT
C CALLED BY CLOCK AT MIDNIGHT; READS THREAT FOR APPROPRIATE DAY FOR
C EACH ZONE AND SETS CORRESPONDING GLOBAL VARIABLES; CAN STORE DATA
C FOR UP TO 21 DAYS. DAYS ARE "REAL" DAYS BASED ON SIMULATED START
C TIME. USER MUST LOAD THREAT DATA STATEMENT (TOTAL OF 210 ENTRIES).
      COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
      : MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,MNSET,NTAPE,SS(100),SSL(100),
      : TNEXT,TNOW,XX(100)
      INTEGER T(210),DAY
C EXPAND THIS DATA STATEMENT TO USE VARYING THREAT FEATURE:
C FILL IN ZONE 1 (ALL 21 DAYS), THEN ZONE 2 (21 DAYS), ETC.
      DATA T/210*0/
      DAY=XX(30)
      IF (DAY.GT.21) DAY=21
      DO 10 I=1,10
        XX(50+I)=T((I-1)*21+DAY)
10    CONTINUE
      RETURN
      END

```

C SUBROUTINE MXMAIN (MAIN BASE MAINTENANCE EVENT) IS MANDA-
 C TORY FOR EACH ACFT ON COMPLETION OF MAIN BASE 1 OFFLOAD.
 C ENGINES, PROPS, AND OTHER SYSTEMS (GEAR, AVIONICS, ETC.) ARE
 C CHECKED IF ENROUTE ABORTS HAVE INDICATED PROBLEMS WITH THESE
 C SYSTEMS. ALL THREE SYSTEM CATEGORIES ARE ALSO CHECKED ON A
 C RANDOM BASIS TO SIMULATE PROBLEMS WHICH WOULD BE DETECTED ON
 C SHUTDOWN AND THRUFLIGHT INSPECTION AT HOME BASE.
 C SINCE ALL AIRCRAFT ARE CONSTRAINED TO UNDERGO MAINTENANCE
 C AND REFUELING ON EACH ARRIVAL AT HOME BASE, EACH AIRCRAFT WILL
 C BE ASSIGNED A MAINTENANCE/REFUELING TIME ON PASSAGE THROUGH
 C THE MAINTENANCE EVENT. ALL AIRCRAFT MUST UNDERGO MINOR
 C MAINTENANCE AND REFUELING, AND MAY EXPERIENCE ADDITIONAL
 C SYSTEM PROBLEMS IN ONE OR MORE OF THE THREE CATEGORIES LISTED.
 C FOR ENGINES AND PROPS, A PROBLEM CAN BE RESOLVED IN TWO
 C WAYS -- MAJOR ASSEMBLY REPLACEMENT (ENGINE/PROP CHANGE) OR
 C ON-AIRCRAFT REPAIR. IF REPLACEMENT IS INDICATED, THE
 C REQUIRED ITEM IS DEDUCTED FROM THE INVENTORY OF AVAILABLE
 C SPARES; IF THERE ARE NO MORE SPARES, THE AIRCRAFT MUST GO
 C NORS AND BE DEADLINED. SINCE THIS MODEL DOES NOT SIMULATE
 C REPLENISHMENT, NORS AIRCRAFT ARE PERMANENTLY GROUNDED AND
 C USABLE PARTS ARE CANNIBALIZED AND USED TO REPLENISH SPARE
 C INVENTORIES. (CURRENTLY ONLY ENGINES AND PROPS ARE TRACKED
 C IN THIS MANNER.) IF THE PART IS AVAILABLE OR IF ON-AIRCRAFT
 C MAINTENANCE IS INDICATED, A REPAIR TIME IS ASSIGNED IN ADDITION
 C TO THE MINOR MX/REFUELING TIME.
 C FOR PROBLEMS INDICATED IN THE "OTHER" CATEGORY, PARTS ARE
 C NOT TRACKED AND AN AIRCRAFT CANNOT BE GROUNDED FOR PROBLEMS
 C INVOLVING ONLY THESE SYSTEMS. HOWEVER, AN AIRCRAFT CAN BE
 C PLACED IN DEGRADED (PARTIALLY MISSION CAPABLE, OR PMC) STATUS
 C IF REPAIRS CANNOT BE EFFECTED. IN THIS MODEL, PROBLEMS IN
 C THE "OTHER" SYSTEM GROUPING ARE HANDLED ON A FIX-NOW OR FIX-LATER
 C BASIS. ONCE THE PROBLEM IS INDICATED (EITHER BY ABORT OR RANDOM
 C SAMPLING) IT IS EITHER FIXED OR NOT FIXED; IF FIXED, AN ADDITIONAL
 C REPAIR TIME IS ASSIGNED AND THE AIRCRAFT AGAIN BECOMES FULLY
 C MISSION CAPABLE (FMC). IF NOT FIXED, A SMALL "TROUBLESHOOTING"
 C TIME IS ASSIGNED AND THE AIRCRAFT IS RELEASED BACK INTO THE
 C SYSTEM IN A DEGRADED STATUS (ATRIB(2)=2). EACH TIME A PMC
 C AIRCRAFT PASSES THROUGH MAINTENANCE, IT IS AUTOMATICALLY ROUTED
 C THROUGH THE FIX/NO-FIX ROUTINE AND ONCE AGAIN MAY OR MAY NOT BE
 C REPAIRED. PMC AIRCRAFT ARE ALSO GIVEN A 50-50 CHANCE TO RETURN
 C TO MAINTENANCE FROM SCHED IF NOT SCHEDULED FOR A MISSION.
 C (IN THIS WAY, PMC AIRCRAFT CAN RETURN TO FMC STATUS).
 C NOTE: IF AN AIRCRAFT HAS A PROBLEM WITH ENGINES OR PROPS, ANY
 C PREVIOUS PROBLEMS IN THE "OTHER" CATEGORY ARE CONSIDERED FIXED
 C AT THE SAME TIME AS THE ENGINE OR PROP PROBLEM, THUS RETURNING
 C THE AIRCRAFT TO FMC STATUS UNLESS MORE "OTHER" CATEGORY PROBLEMS
 C ARE SUBSEQUENTLY "DISCOVERED" BY THE RANDOM SELECTION PROCESS.
 C REFUELING TIME IS ADDED TO ANY MAINTENANCE SERVICE TIME;
 C OFFLOAD, MAINTENANCE, AND REFUELING OPERATIONS MAY NOT BE
 C CONCURRENT, ALTHOUGH ANY NUMBER OF AIRCRAFT MAY BE SERVICED
 C SIMULTANEOUSLY IN ANY ACTIVITY. THE RANDOM PROBABILITY OF A
 C MAJOR SYSTEM PROBLEM (IF SUCH A PROBLEM IS NOT ALREADY INDICATED
 C BY PREVIOUS ABORT STATUS) IS 15%, BROKEN DOWN INTO 4% EACH FOR
 C ENGINES AND PROPS AND 7% FOR "OTHER". THE PROBABILITY OF
 C REPLACEMENT FOR ENGINES AND PROPS (GIVEN A PROBLEM) IS 10%

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C FOR EACH. PROBABILITY OF REPAIR FOR A PROBLEM IN "OTHER"
C SYSTEMS (GIVEN A PROBLEM) IS 50%.
C
C VARIABLES:
C      A(40)      REAL      AIRCRAFT ATRIS
C      NACFT      INT       ACFT ID NUMBER
C      GNDTIM     REAL      TIME SINCE ARRIVING IN
C                          OFFLOAD AREA
C      FIXTIM     REAL      CUMULATIVE REPAIR AND
C                          REFUEL TIME
C      FUEL       REAL      FUEL USED
C      X1,X2,X3,
C      Z1,Z2,Z3 REAL      RANDOM VARIATES
C
SUBROUTINE MMMAIN
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NMSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
REAL A(40)
NACFT=ATRIB(8)
C CHECK FOR MISSION COMPLETION (MISSION IS COMPLETE AT HOME BASE
C ON COMPLETION OF OFFLOAD AND PRIOR TO BEGINNING OF MX TIME)
IF (ATRIB(37).EQ.0) ATRIB(37)=88888
IF (ATRIB(23).EQ.0) CALL MTRACE(14)
C SET A=ATRIB FOR CONVENIENCE
DO 5 I=1,40
    A(I)=ATRIB(I)
5 CONTINUE
C ALL ACFT REQUIRE MINOR MX (5 TO 30 MIN)
A(17)=UNFRM(5.,30.,1)
GNDTIM=TNOW-A(4)
X1=UNFRM(0.,100.,1)
X2=UNFRM(0.,100.,1)
X3=UNFRM(0.,100.,1)
Z1=UNFRM(0.,100.,1)
Z2=UNFRM(0.,100.,1)
Z3=UNFRM(0.,100.,1)
C CHECK ENGINES IF A18=3 (ABORTED FOR ENGINE)
IF (A(18).EQ.3.OR.X1.LE.4) THEN
C NOT WINTER
IF (XX(31).NE.3) THEN
C IF ENGINE CHANGE, CHECK ENGINES IN STOCK;
IF (Z1.LE.10) THEN
C IF NONE IN STOCK, PRINT NORS MSG AND CAN GOOD PARTS
IF (XX(3).EQ.0) THEN
IF (XX(99).GE.1) PRINT 3000, TNOW, NACFT
XX(3)=XX(3)+3
XX(4)=XX(4)+4
GO TO 999
ENDIF
C IF ENG AVAIL, DECR STOCK, SET FIXTIM, PRINT MSG
XX(3)=XX(3)-1
FIXTIM=TRIAC(120.,240.,480.,1)
IF (XX(99).GE.1) PRINT 3001, TNOW, XX(3), FIXTIM, NACFT
A(17)=A(17)+FIXTIM

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```

ELSE
C   FOR NON-ENGINE CHANGE, SET FIXTIM
      FIXTIM=TRIAC(0.,30.,120.,1)
      A(17)=A(17)+FIXTIM
ENDIF
ENDIF
C   REPEAT FOR WINTER (LONGER REPAIR TIMES)
IF (XX(31).EQ.3) THEN
C   IF ENGINE CHANGE, CHECK ENGINES IN STOCK;
      IF (Z1.LT.10) THEN
C   IF NONE IN STOCK, PRINT NORS MSG AND CAN GOOD PARTS
          IF (XX(3).EQ.0) THEN
              IF (XX(99).GE.1) PRINT 3000,TNOW,NACFT
              XX(3)=XX(3)+3
              XX(4)=XX(4)+4
              GO TO 999
          ENDIF
C   IF ENG AVAIL, DECR STOCK, SET FIXTIM, PRINT MSG
          XX(3)=XX(3)-1
          FIXTIM=TRIAC(120.,360.,720.,1)
          IF (XX(99).GE.1) PRINT 3001,TNOW,XX(3),FIXTIM,NACFT
          A(17)=A(17)+FIXTIM
      ELSE
C   FOR NON-ENGINE CHANGE, SET FIXTIM
          FIXTIM=TRIAC(0.,40.,210.,1)
          A(17)=A(17)+FIXTIM
      ENDIF
      ENDIF
      A(2)=1
      ENDIF
C   REPEAT FOR PROPS
      IF (A(18).EQ.4.OR.X2.LE.4) THEN
C   NON-WINTERTIME
          IF (XX(31).NE.3) THEN
C   IF PROP CHANGE, CHECK PROPS IN STOCK;
              IF (Z2.LT.10) THEN
C   IF NONE IN STOCK, PRINT NORS MSG AND CAN GOOD PARTS
                  IF (XX(4).EQ.0) THEN
                      IF (XX(99).GE.1) PRINT 4000,TNOW,NACFT
                      XX(3)=XX(3)+4
                      XX(4)=XX(4)+3
                      GO TO 999
                  ENDIF
C   IF PROP AVAIL, DECR STOCK, SET FIXTIM, PRINT MSG
                  XX(4)=XX(4)-1
                  FIXTIM=TRIAC(120.,240.,480.,1)
                  IF (XX(99).GE.1) PRINT 4001,TNOW,XX(4),FIXTIM,NACFT
                  A(17)=A(17)+FIXTIM
              ELSE
C   FOR NON-PROP CHANGE, SET FIXTIM
                  FIXTIM=TRIAC(0.,30.,120.,1)
                  A(17)=A(17)+FIXTIM
              ENDIF
          ENDIF
      ENDIF
      REPEAT FOR WINTER

```

```

      IF (XX(31).EQ.3) THEN
C      IF PROP CHANGE, CHECK PROPS IN STOCK;
      IF (X2.LT.10) THEN
C      IF NONE IN STOCK, PRINT NORS MSG AND CAN GOOD PARTS
      IF (XX(4).EQ.0) THEN
        IF (XX(99).GE.1) PRINT 4000,TNOW,NACFT
        XX(3)=XX(3)+4
        XX(4)=XX(4)+3
        GO TO 999
      ENDIF
C      IF PROP AVAIL, DECR STOCK, SET FIXTIM, PRINT MSG
      XX(4)=XX(4)-1
      FIXTIM=TRIAG(120.,360.,720.,1)
      IF (XX(99).GE.1) PRINT 4001,TNOW,XX(4),FIXTIM,NACFT
      A(17)=A(17)+FIXTIM
      ELSE
C      FOR NON-PROP CHANGE, SET FIXTIM
      FIXTIM=TRIAG(0.,40.,210.,1)
      A(17)=A(17)+FIXTIM
      ENDIF
    ENDIF
    A(2)=1
  ENDIF
C CHECK FOR OTHER SYSTEMS
  IF (A(18).EQ.5.OR.A(2).EQ.2.OR.X3.LE.7) THEN
C    NON-WINTERTIME
    IF (XX(31).NE.3) THEN
C      REPAIR POSTPONED; ACFT TO DEGRADED STATUS
      IF (Z3.LE.50) THEN
        FIXTIM=TRIAG(0.,20.,40.,1)
        A(2)=2
        A(17)=A(17)+FIXTIM
C      REPAIR NOW; ACFT RETURNED TO FMC STATUS
      ELSE
        FIXTIM=TRIAG(15.,60.,120.,1)
        A(2)=1
        A(17)=A(17)+FIXTIM
      ENDIF
C    WINTERTIME
    ELSE
C      REPAIR POSTPONED; ACFT TO DEGRADED STATUS
      IF (Z3.LE.50) THEN
        FIXTIM=TRIAG(0.,40.,80.,1)
        A(2)=2
        A(17)=A(17)+FIXTIM
C      REPAIR NOW; ACFT RETURNED TO FMC STATUS
      ELSE
        FIXTIM=TRIAG(30.,120.,240.,1)
        A(2)=1
        A(17)=A(17)+FIXTIM
      ENDIF
    ENDIF
  ENDIF
C REFUEL BASED ON FUEL BURN RATE OF 4000 LBS/HR (75 LBS/MIN) AND
C REFUEL RATE OF 1200 LBS/MIN WITH 10 MIN CONN/DISCONN TIME

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C ALL ACFT LEAVE HOME BASE WITH 50000 LBS/11 HRS FUEL.
  FUEL=A(3)*75
  CALL COLCT(FUEL,1)
  CALL COLCT(A(3),2)
  A(17)=A(17)+10+FUEL/1200
C UPDATE TOTAL ACFT FLY TIME (FOR UTILIZATION RATE STATISTICS);
C RESET MSN FLY TIME, ACFT BEGIN-MX MARK TIME, ROUTING SWITCH,
C AND ABORT SYSTEM (MIFAIL) FLAG.
  A(5)=A(5)+A(3)
  A(3)=0
  IF (A(18).EQ.100) A(1)=TNOW
  A(11)=0
  A(16)=1
  A(18)=0
C CHANGE A TO ATRIB
  DO 20 I=1,40
    ATRIB(I)=A(I)
20  CONTINUE
  RETURN
C FOR NORS ACFT, SET SWITCH TO RETURN CREW TO CREW REST, ACFT TO
C DEAD FILE; DECREMENT ACFT IN SYSTEM
999  A(16)=0
      DO 1000 I=1,40
        ATRIB(I)=A(I)
1000  CONTINUE
      XX(1)=XX(1)-1
C IF NORS ACFT MSN NOT COMPLETE, ENTER CONTINUATION MISSION
  IF (ATRI(23).GE.1) THEN
    ATRIB(21)=AMAX1(ATRI(21),ATRI(22),ATRI(25))
    CALL RESCH
  ENDIF
  RETURN
3000  FORMAT (1X,F7.1,' ACFT NORS FOR ENGINE -- ACFT# ',I2)
3001  FORMAT (1X,F7.1,' ENGINE CHANGE, ',F3.0,' REMAINING,',
:          ' FIXTIM=',F5.0,' ACFT# ',I2)
4000  FORMAT (1X,F7.1,' ACFT NORS FOR PROPS -- ACFT# ',I2)
4001  FORMAT (1X,F7.1,' PROP CHANGE, ',F3.0,' REMAINING,',
:          ' FIXTIM=',F5.0,' ACFT# ',I2)
  END

```

C SUBROUTINE RESCUE HANDLES AIRCRAFT GROUNDED ENROUTE.
 C MANY C-130 ENGINE AND PROPELLER PROBLEMS OCCUR ON ENGINE
 C SHUTDOWN OR START. FOR THIS REASON, SHUTDOWN FOR OFFLOAD
 C OR ONLOAD AT ISOLATED BASES WITH AUSTERE FACILITIES IS
 C NORMALLY DISCOURAGED, PARTICULARLY IF GROUND TIMES CAN
 C BE KEPT REASONABLE (LESS THAN 30 TO 45 MINUTES). THIS
 C PROBLEM IS AGGRAVATED IN COLD WEATHER WHEN ENGINES/PROPS/
 C HYDRAULICS ARE SHUT DOWN LONG ENOUGH TO BECOME COLD-SOAKED.
 C IF PROBLEMS ARE SEVERE ENOUGH, THE AIRPLANE MAY BE GROUNDED
 C AND MAY REQUIRE MAINTENANCE FROM HOME BASE, WHICH IN TURN
 C USUALLY REQUIRES THAT A SPECIAL MISSION BE GENERATED; SUCH
 C MISSIONS ARE COMMONLY KNOWN AS "RESCUE" MISSIONS. PROBLEMS
 C NOT SERIOUS ENOUGH FOR GROUNDING MAY REQUIRE THAT THE AIR-
 C CRAFT BE ABORTED TO HOME BASE, OR MAY SIMPLY RESULT IN
 C EXTRA DELAY FOR TROUBLESHOOTING AND POSSIBLY A QUICK FIX
 C BY THE CREW.
 C THIS MODEL ASSUMES THAT ENGINES ARE SHUT DOWN IF GROUND
 C TIME EXCEEDS 45 MINUTES. THE AIRCRAFT RUNS A RISK OF TROUBLE
 C ON BOTH SHUTDOWN AND START, WITH DIFFERING PROBABILITIES FOR
 C EACH SITUATION AND FOR WINTER AND NON-WINTER CONDITIONS.
 C IF THE PROBLEMS DO NOT REQUIRE ABORT OR GROUNDING, THE AIR-
 C CRAFT IS SIMPLY DELAYED BEFORE RESUMING ITS SCHEDULED MISSION.
 C IF THE PROBLEMS DO NOT REQUIRE GROUNDING BUT DO REQUIRE AN
 C ABORT TO HOME BASE, THE AIRCRAFT IS BOTH DELAYED AND REROUTED
 C DIRECTLY HOME.
 C AN ABORTING AIRCRAFT WILL COMPLETE OFFLOAD (IF ANY), BUT
 C WILL NOT ONLOAD UNLESS THE LOAD IS FOR HOME BASE. IF THE
 C AIRCRAFT IS ALREADY LOADED (NORMALLY THE CASE FOR START
 C PROBLEMS) THE LOAD IS KEPT ON BOARD -- EXPERIENCE HAS PROVEN
 C THAT MISSIONS CAN USUALLY BE REROUTED MORE EFFICIENTLY FROM
 C HOME BASE, AND THAT A PROBLEMS ALLOWING TAKEOFF RARELY REQUIRE
 C THAT THE AIRCRAFT BE EMPTY. (HOWEVER, THE MODEL ASSUMES THAT
 C THE ABORTING AIRCRAFT WILL REQUIRE MAINTENANCE AT HOME BASE,
 C AND ACCORDINGLY CAUSES ALL ABORTING AIRCRAFT TO BE DOWN
 C LOADED AT HOME BASE.) IF THE AIRCRAFT HAS NOT BEGUN LOADING
 C (PROBLEMS OCCURRING ON SHUTDOWN)
 C IF THE AIRCRAFT IS GROUNDED, IT IS FIRST DOWNLOADED (WITH
 C A 30-MINUTE DELAY TO SIMULATE THE NORMAL UNCERTAINTY EXISTING
 C BEFORE DECIDING THAT THE AIRPLANE IS INCAPABLE OF FLIGHT).
 C AFTER DOWNLOADING, A RESCUE MISSION IS REQUESTED FROM HOME
 C BASE. ON ARRIVAL OF THE RESCUE MISSION, THE "RESCUER" OFF-
 C LOADS THE MAINTENANCE LOAD AND BECOMES FREE FOR SCHEDULING.
 C THE "RESCUEE" THEN BEGINS TO MAKE REPAIRS (WHICH ARE USUALLY
 C LENGTHY, PARTICULARLY IN WINTER). ON COMPLETION OF REPAIRS,
 C THE REPAIRED AIRCRAFT RETURNS TO HOME BASE WITH THE MAINTEN-
 C ANCE PACKAGE ON BOARD.
 C IN THIS MODEL, SUBROUTINE CONTIN CHECKS FOR SHUTDOWN
 C PROBLEMS AND SUBROUTINE RESTRT CHECKS FOR START PROBLEMS;
 C SEE CONTIN AND RESTRT FOR CONDITIONS AND PERCENTAGES USED.
 C
 C VARIABLES:
 C LOC INT CURRENT ACFT LOCATION
 C NACFT INT ACFT ID NUMBER
 C A(40) REAL ATRIBS FOR RESCUE MISSION
 C

```

SUBROUTINE RESCUE
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
REAL A(40)
LOC=ATRIB(15)
NACFT=ATRIB(9)
C NEWLY GROUNDED AIRCRAFT HAS COMPLETED OFFLOAD; RETURN
C MISSION TO CURRENT BASE MISSION FILE FOR PICKUP BY
C OTHER AIRCRAFT.
IF (XX(98).GE.1) PRINT 3000,TNOW,NINT(ATRIB(37)),LOC,
: ATRIB(18),NACFT
IF (ATRIB(18).NE.1) THEN
IF (ATRIB(11).EQ.1) THEN
CALL RESCH
ATRIB(37)=90000+LOC*1000+XX(30)*100+XX(26)
ENDIF
C SET UP AND REQUEST RESCUE MISSION
DO 10 I=1,40
A(I)=0
10 CONTINUE
A(1)=TNOW
IF (LOC.GE.4) A(2)=1
IF (LOC.LE.3) A(2)=2
A(3)=95000+LOC*1000+XX(30)*100+XX(26)
A(4)=2
A(5)=0
A(20)=1
A(21)=8
A(22)=8
A(23)=LOC
CALL SCHUL(2,0.,A)
IF (XX(98).GE.1) PRINT 1000, TNOW,NINT(A(3)),
: NINT(ATRIB(37)),LOC,NACFT
C ROUTE AIRCRAFT TO AWAIT-RESCUE LOOP
ATRIB(18)=1
ATRIB(16)=1
RETURN
ENDIF
C RESCUED AIRCRAFT BEGINS REPAIRS; SET REPAIR TIME, LOAD
C AIRCRAFT WITH MAINTENANCE PACKAGE, AND ROUTE TO HOME
C BASE.
IF (ATRIB(18).EQ.1) THEN
IF (XX(31).NE.3) THEN
IF (ATRIB(18).EQ.3) ATRIB(17)=
: TRIAG(240.,480.,720.,1)
IF (ATRIB(18).EQ.4) ATRIB(17)=
: TRIAG(180.,360.,600.,1)
IF (ATRIB(18).EQ.5) ATRIB(17)=
: TRIAG(180.,360.,600.,1)
ELSE
IF (ATRIB(18).EQ.3) ATRIB(17)=
: TRIAG(360.,720.,1200.,1)
IF (ATRIB(18).EQ.4) ATRIB(17)=
: TRIAG(240.,720.,1200.,1)

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      IF (ATRI(18).EQ.5) ATRI(17)=
      TRIAC(240.,480.,720.,1)
    ENDIF
    IF (XI(98).GE.1) PRINT 2000, TNOW, LOC,
      ATRI(17), NACFT
      ATRI(11)=2
      ATRI(12)=LOC
      ATRI(13)=8
      ATRI(14)=8
      ATRI(15)=1
      ATRI(18)=0
      RETURN
    ENDIF
1000  FORMAT(1X,F7.1,' RESCUE MSN ',I5,' INPUT FOR MSN ',
      :      I5,' AT BASE ',I1,' ACFT# ',I2)
2000  FORMAT(1X,F7.1,' RESCUE MSN OFFLOADED AT BASE ',I1,
      :      ' -- FIXTIM=',F3.0,' ACFT# ',I2)
3000  FORMAT(1X,F7.1,' MSN ',I5,' AWAITING RESCUE AT ',I1,
      :      ' -- MXFAIL=',F2.0,' ACFT# ',I2)
C12345.7 RESCUE MSN 97123 INPUT FOR MSN 12345 AT BASE 3 ACFT# 12
C12345.7 RESCUE MSN OFFLOADED AT BASE 5 -- FIXTIM=1234. ACFT# 13
C12345.7 MSN 12345 AWAITING RESCUE AT 3 -- MXFAIL=3 ACFT# 4
    END

```

C WHEN EACH AIRCRAFT HAS COMPLETED THE ARRIVAL CYCLE AT
 C A BASE, IT IS ROUTED TO CONTIN, WHICH CHECKS FOR MORE
 C LEGS TO BE FLOWN:
 C IF MORE LEGS, ALL LEG DATA IS SHIFTED DOWN, SO THAT
 C CURRENT LEG DATA IS REPLACED BY NEXT LEG DATA, ETC.
 C AS THE MISSION DATA IS SHIFTED DOWN, VACATED LEG DATA
 C SLOTS ARE FILLED WITH ZEROS. WITH ATTRIBUTES ADJUSTED,
 C THE AIRCRAFT IS ROUTED TO THE DEPARTURE CYCLE FOR ITS
 C CURRENT LOCATION.
 C IF NO MORE LEGS (NEXT DESTINATION IS ZERO), THE
 C AIRCRAFT HAS COMPLETED ITS ASSIGNED MISSION AND IS
 C AVAILABLE FOR RESCHEDULING. MISSION ATTRIBUTES ARE
 C "CLEANED UP" AND THE AIRCRAFT IS ROUTED TO THE
 C SCHEDULER.
 C BEFORE ANY MISSION CONTINUATION CHECKS ARE MADE,
 C HOWEVER, MAINTENANCE CHECKS ARE MADE. FIRST, NON-ENGINE/
 C PROP SYSTEMS ("OTHER" SYSTEMS) ARE CHECKED. NEXT, A
 C CHECK IS MADE TO SEE IF THE AIRCRAFT COULD BE EXPECTED
 C TO SHUT DOWN ENGINES. IF GROUND TIME FOR OFFLOAD HAS
 C ALREADY EXCEEDED 30 MINUTES, OR IF AN ONLOAD IS SCHEDULED,
 C OR IF THE AIRCRAFT HAS FINISHED ITS MISSIONS BUT MISSIONS
 C ARE WAITING AT THE CURRENT BASE, THEN THE AIRCRAFT
 C IS ASSUMED TO HAVE SHUT DOWN ENGINES, WITH A RISK OF
 C PROBLEMS ON SHUTDOWN (THE MODEL ASSUMES THAT EITHER
 C ENGINES OR PROPS MAY HAVE PROBLEMS, BUT NOT BOTH).
 C FOR SHUTDOWN PROBLEMS, THE MODEL ASSUMES THAT ENGINES
 C AND PROPS ARE AT OPERATING TEMPERATURE WHEN SHUT DOWN,
 C AND SO DOES NOT DIFFERENTIATE BETWEEN SUMMER AND WINTER.
 C (FOR ENGINE START (SEE RESTR) WINTER AND NON-WINTER
 C AMBIENT TEMPERATURES ARE TAKEN INTO ACCOUNT, SINCE
 C PROPULSION SYSTEMS WILL HAVE HAD A CHANCE TO COOL DOWN,
 C AND PERHAPS TO BECOME COLD-SOAKED.
 C IT IS ASSUMED THAT AIRCRAFT WOULD BE ABLE TO
 C OFFLOAD CARGO EVEN WITH PROPULSION PROBLEMS, BUT THAT
 C ONLOAD OR RESCHEDULING WOULD PROBABLY BE DELAYED
 C UNTIL THE NATURE OF PROBLEM IS DIAGNOSED AND ANY
 C NECESSARY REPAIRS ARE MADE. IF PROBLEMS ARE SERIOUS
 C ENOUGH TO REQUIRE THE AIRCRAFT TO RETURN HOME, ONLOADS
 C ARE CANCELLED AND ANY CARGO REMAINING ON THE AIRCRAFT
 C INTENDED FOR SUBSEQUENT BASES IS RETURNED TO THE MAIN
 C BASE IN AN ABORTED-MISSION STATUS. IN ANY CASE, A
 C MAINTENANCE PROBLEM REQUIRES SOME TIME TO DIAGNOSE AND/
 C OR REPAIR, AND ROUTING TO THE SCHEDULER OR TO THE
 C DEPARTURE PHASE WILL BE APPROPRIATELY DELAYED.
 C IF PROBLEMS ARE SERIOUS ENOUGH TO GROUND THE AIRCRAFT
 C AT AN ENROUTE BASE, THE "RESCUE" SEQUENCE IS INITIATED
 C (SEE DISCUSSION UNDER SUBROUTINE RESCUE). GROUNDING
 C IS NOT ALLOWED AT BASE 4 OR 5.
 C VARIABLES:
 C NACFT INT ACFT ID NUMBER
 C MSN INT MISSION NUMBER
 C LOC INT CURRENT ACFT LOCATION
 C GNDTIM REAL TIME SINCE ARRIVAL IN
 C OFFLOAD AREA
 C X, X1, Z1 REAL RANDOM VARIATES

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C
SUBROUTINE CONTIN
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,MNSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
NACFT=ATRIB(9)
MSN=ATRIB(37)
C IF AIRDROP (BASE 4 OR 5 ONLY) SHIFT ATTRIBUTES AND ROUTE TO
C ENROUTE.
IF (ATRIB(14).EQ.5.OR.ATRIB(14).EQ.(6)) THEN
IF (ATRIB(15).GE.4) THEN
ATRIB(11)=0
ATRIB(12)=ATRIB(15)
ATRIB(13)=7
ATRIB(14)=7
ATRIB(15)=1
ATRIB(16)=1
ATRIB(17)=10
ATRIB(20)=1
DO 10 K=21,34
ATRIB(K)=0
10 CONTINUE
ATRIB(40)=2
IF (XX(98).GE.1) PRINT 1000,TNOW,MSN,
: NINT(ATRIB(12)),NACFT
CALL MTRACE(2)
RETURN
ENDIF
ENDIF
1000 FORMAT(1X,F7.1,' MSN ',15,' AIRDROP COMPLETE AT ',11,
: ' ACFT# ',12)
C NON-AIRDROP MISSIONS; FIRST CHECK MAINTENANCE PROBLEMS
LOC=ATRIB(15)
ATRIB(17)=0
C MX CHECK NOT PERFORMED AT HOME BASE -- REGULAR MX
C ROUTINE TAKES THIS INTO ACCOUNT
IF (LOC.EQ.1) GO TO 300
C CHECK FOR "OTHER" SYSTEM PROBLEMS; IF A MAX-EFFORT
C LANDING HAS BEEN MADE, POSSIBLE BRAKE/GEAR/TIRE PROBLEMS
C RESULT IN A HIGHER PROBABILITY OF DIFFICULTY.
X1=UNFRM(0.,100.,1)
Z1=UNFRM(0.,100.,1)
C CHECK FOR MAX-EFFORT PROBLEMS
IF (LOC.GE.4) THEN
C DELAY ONLY
IF (X1.LT.3) ATRIB(17)=TRIAC(0.,15.,30.,1)
C ABOUT TO HOME BASE (FLYABLE) PLUS DELAY
IF (X1.GT.99) THEN
ATRIB(18)=5
ATRIB(17)=TRIAC(0.,20.,40.,1)
GO TO 500
ENDIF
ENDIF
C CHECK FOR NON-MAX-EFFORT PROBLEMS
IF (LOC.LE.3) THEN

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C DELAY ONLY
  IF (X1.LT.2.5) ATRIB(17)=TRIAG(0.,15.,30.,1)
C ABORT TO HOME BASE (FLYABLE) PLUS DELAY
  IF (X1.GT.99) THEN
    ATRIB(18)=5
    ATRIB(17)=TRIAG(0.,20.,40.,1)
    GO TO 500
  ENDIF
ENDIF
C CHECK FOR ENGINE SHUTDOWN
  GNDTIM=TNOW-ATRI(4)
  IF (GNDTIM.LT.30.AND.ATRI(21).LE.2) THEN
    IF (ATRI(23).NE.0.OR.NNQ(LOC).EQ.0) GO TO 300
  ENDIF
C CHECK ENGINES AND PROPS FOR SHUTDOWN PROBLEMS (TOTAL
C   PROB OF DIFFICULTY IS 5%)
C CHECK ENGINES (TOTAL PROB 3%)
  X=UNFRM(0.,100.,1)
C DELAY ONLY (2.25%)
  IF (X.LE.2.25) ATRIB(17)=TRIAG(0.,15.,30.,1)
C GROUNDING PROBLEM (0.25%)
  IF (X.GT.99.75.AND.LOC.LE.3) THEN
    ATRIB(18)=3
    GO TO 700
  ENDIF
C ABORT TO HOME BASE (FLYABLE) (0.75%)
  IF (X.GT.99) THEN
    ATRIB(17)=TRIAG(0.,15.,30.,1)
    ATRIB(18)=3
    GO TO 500
  ENDIF
C SAME SEQUENCE FOR PROPS (TOTAL PROB 2%)
  X=UNFRM(0.,100.,1)
C DELAY ONLY (1.25%)
  IF (X.LE.1.25) ATRIB(17)=TRIAG(0.,15.,30.,1)
C GROUNDING PROBLEM (0.25%)
  IF (X.GT.99.75.AND.LOC.LE.3) THEN
    ATRIB(18)=4
    GO TO 700
  ENDIF
C ABORT TO HOME BASE (FLYABLE) (0.5%)
  IF (X.GT.99.5) THEN
    ATRIB(17)=TRIAG(0.,15.,30.,1)
    ATRIB(18)=4
    GO TO 500
  ENDIF
C CHECK FOR MISSION CONTINUATION; IF NEXT DEST=0, MSN COMPLETE --
C ROUTE TO SCHEDULER WITH "CLEAN SLATE". IF MISSION IS COMPLETE
C CALL MTRACE(14) TO PRINT MISSION COMPLETION MESSAGE. (NOTE:
C MSN COMPLETION AT HOME BASE IS CHECKED AT BEGINNING OF MXMAIN,
C IMMEDIATELY ON COMPLETION OF OFFLOAD.)
300  ATRIB(12)=ATRI(15)
  IF (ATRI(23).EQ.0) THEN
    IF (LOC.NE.1) CALL MTRACE(14)
    DO 20 I=18,48

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        ATRIB(I)=0
20      CONTINUE
        ATRIB(13)=0
        ATRIB(14)=0
        ATRIB(18)=0
        RETURN
      ENDIF
C IF MISSION NOT COMPLETE, SHIFT ALL MISSION DATA DOWN ONE LEG
C AND ROUTE TO DEPARTURE.
25      ATRIB(13)=ATRI(21)
        ATRIB(14)=ATRI(22)
        ATRIB(15)=ATRI(23)
        DO 30 I=20,29
          ATRIB(I)=ATRI(I+3)
30      CONTINUE
        DO 31 I=30,32
          ATRIB(I)=0
31      CONTINUE
        ATRIB(18)=1
        CALL MTRACE(2)
        RETURN
C ABORTS TO HOME BASE
C ABORT CODE (ATRI(11))= 1 LOADED, NON-HOME MSN
C                      2 EMPTY
C                      3 LOADED, THROUGH-HOME MSN
C                      4 LOADED, END-HOME MSN
C IF MISSION COMPLETE, CALL MTRACE(14)
500     ATRIB(2)=3
        ATRIB(11)=1
        IF (ATRI(23).EQ.0) THEN
          CALL MTRACE(14)
          ATRIB(11)=2
          ATRIB(13)=0
          ATRIB(14)=0
          ATRIB(37)=70000+LOC*1000+XX(30)*100+XX(26)
          GO TO 699
        ENDIF
C IF SCHEDULED TO BEGIN MISSION AT CURRENT BASE BUT
C HAVE ABORTED, CANCEL ONLOAD AND RETURN INTENDED
C MISSION TO MISSION FILE (SPECIAL CASE: MISSIONS
C INTENDED TO RETURN TO OR THROUGH HOME BASE CAN BE
C LOADED).
        IF (ATRI(13).EQ.0.AND.ATRI(14).EQ.0) THEN
          IF (ATRI(23).GE.2) THEN
            IF (XX(90).GE.1) PRINT 2000,TNOW,
              NINT(ATRI(37)),LOC,NACFT
            CALL RESCH
            ATRIB(37)=70000+LOC*1000+XX(30)*100+XX(26)
            GO TO 699
          ENDIF
        ENDIF
C FOR MISSIONS ALREADY SCHEDULED TO GO TO HOME BASE
C WHICH ABORT, SHIFT LEG INFO AS FOR NORMAL MISSION,
C BUT SET ABORT FLAG (A11) TO 3 IF MORE STOPS AFTER
C HOME AND 4 IF MISSION WAS TO TERMINATE AT HOME.

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C (THROUGH-HOME MISSIONS WILL BE COMPLETELY OFFLOADED
C AND RE-ENTERED AT HOME, SINCE THE AIRCRAFT IS
C ASSUMED TO BE IN NEED OF MAINTENANCE).
600 IF (ATTRIB(23).EQ.1) THEN
    ATTRIB(13)=ATTRIB(21)
    ATTRIB(14)=AMAX1(ATTRIB(21),ATTRIB(22),ATTRIB(25))
    DO 601 K=20,29
        ATTRIB(K)=ATTRIB(K+3)
601 CONTINUE
    DO 602 K=30,32
        ATTRIB(K)=0
602 CONTINUE
    IF (ATTRIB(23).GE.2) THEN
        ATTRIB(21)=AMAX1(ATTRIB(21),ATTRIB(22),ATTRIB(25))
        ATTRIB(11)=3
    ELSE
        ATTRIB(11)=4
    ENDIF
    GO TO 699
ENDIF
C IF IN MID-MISSION, LEAVE CARGO FOR SUBSEQUENT BASES
C ON ACFT, BUT RESTRUCTURE ATTRIBUTES FOR OFFLOAD AND
C RE-ENTRY OF MISSION AT HOME BASE. (ASSUME OFFLOAD
C FOR CURRENT BASE COMPLETED AS PLANNED.)
    ATTRIB(13)=AMAX1(ATTRIB(13),ATTRIB(21),ATTRIB(22))
    ATTRIB(14)=ATTRIB(13)
    ATTRIB(11)=1
    ATTRIB(20)=1
699 ATTRIB(12)=ATTRIB(15)
    ATTRIB(15)=1
    ATTRIB(16)=1
    IF (XX(98).GE.1) PRINT 2000,TNOW,NINT(ATTRIB(37)),LOC,NACFT
    CALL MTRACE(10)
    RETURN
C IF AIRCRAFT IS GROUNDED, SET UP MISSION ATTRIBUTES FOR
C OFFLOAD AT CURRENT BASE AND REENTRY INTO MISSION FILE.
700 ATTRIB(17)=0
    ATTRIB(2)=3
    ATTRIB(18)=99
C CHECK FOR EMPTY AIRCRAFT (MISSION COMPLETED)
    IF (ATTRIB(23).EQ.0) THEN
        IF (ATTRIB(13).GT.0.OR.ATTRIB(14).GT.0) CALL MTRACE(14)
        ATTRIB(11)=2
        ATTRIB(13)=0
        ATTRIB(14)=0
        ATTRIB(37)=70000+LOC*1000+XX(30)*100+XX(28)
        IF (XX(98).GE.1) PRINT 3000,TNOW,NINT(ATTRIB(37)),LOC,
            NACFT
        CALL MTRACE(9)
        RETURN
    ENDIF
C CHECK FOR POSITION LEG, ABORTING BEFORE MISSION CAN
C BE PICKED UP (INTENDED MISSION IMMEDIATELY AVAILABLE
C FOR PICKUP BY ANOTHER AIRCRAFT).
    IF (ATTRIB(13).EQ.0.AND.ATTRIB(14).EQ.0) THEN

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```

      IF (XX(98).GE.1) PRINT 3000,TNOW,NINT(ATTRIB(37)),LOC,
      NACFT
      CALL RESCH
      ATTRIB(11)=2
      ATTRIB(37)=70000+LOC*1000+XX(30)*100+XX(28)
      CALL MTRACE(9)
      RETURN
    ENDIF
  C IF NONE OF THE ABOVE, CARGO MUST BE OFFLOADED
  ATTRIB(14)=AMAX1(ATTRIB(13),ATTRIB(22))
  ATTRIB(21)=ATTRIB(14)
  ATTRIB(11)=1
  IF (XX(98).GE.1) PRINT 3000,TNOW,NINT(ATTRIB(37)),LOC,NACFT
  ATTRIB(37)=70000+LOC*1000+XX(30)*100+XX(28)
  CALL MTRACE(9)
  RETURN
2000  FORMAT (1X,F7.1,' MSN ',15,' GND ABORTED (SHUTDOWN) AT ',11,
      ' ACFT# ',12)
3000  FORMAT (1X,F7.1,' MSN ',15,' GROUNDED (SHUTDOWN) AT ',11,
      ' ACFT# ',12)
      END

```

C SUBROUTINE RESTRT CHECKS FOR START PROBLEMS ON ANY
 C AIRCRAFT WHICH HAS SHUT DOWN ENGINES (GNDTIM LONGER
 C THAN 45 MIN). ACFT ALREADY ABORTING FOR SHUTDOWN
 C PROBLEMS MUST ALSO BE CHECKED AND COULD BE GROUNDED.
 C (START PROBLEMS AFFECT ALL AIRCRAFT, REGARDLESS.)
 C SINCE ENGINES AND PROPS COOL RAPIDLY ONCE SHUT DOWN,
 C AMBIENT TEMPS CAN MAKE A DIFFERENCE IN PROBABILITY
 C OF STARTUP PROBLEMS OCCURRING (THE MODEL DIFFERENTIATES
 C BETWEEN SUMMER AND WINTER FOR THIS PURPOSE).
 C NOTE: AIRCRAFT AT FORWARD BASES (4 AND 5) ARE NOT
 C ALLOWED TO BE GROUNDED BECAUSE OF THREAT AND MISSION
 C FLOW CONSIDERATIONS. IT IS ASSUMED THAT IN WARTIME
 C AN AIRCRAFT COULD BE FLOWN TO HOME BASE EVEN WITH SERIOUS
 C PROBLEMS, INCLUDING THE LOSS OF AN ENGINE OR PROP (MAC
 C CREWS PRACTICE 3-ENGINE TAKEOFFS FOR THIS PURPOSE).
 C IMMEDIATE DEPARTURE FROM NON-FORWARD BASES IS NOT
 C CONSIDERED TO BE NECESSARY.

C
 C VARIABLES:
 C NACFT INT ACFT ID NUMBER
 C LOC INT CURRENT ACFT LOCATION
 C GNDTIM INT TIME SINCE ARRIVAL IN
 C OFFLOAD AREA
 C X REAL RANDOM VARIATE
 C

SUBROUTINE RESTRT
 COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
 : MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),
 : SSL(100),TNEXT,TNOW,XX(100)
 NACFT=ATRIB(9)
 LOC=ATRIB(12)
 IF (ATRIB(33).EQ.99) GO TO 700
 GNDTIM=TNOW-ATRIB(4)
 ATRIB(17)=0
 ATRIB(33)=0
 IF (GNDTIM.GT.45) THEN
 C IF ENGINES HAVE BEEN SHUT DOWN, NEED 10 MINUTES TO RUN
 C ENGINE START CHECKLIST.
 ATRIB(17)=10
 C CHECK FOR STARTUP PROBLEMS
 C SUMMER PROBABILITIES (TOTAL PROB OF DIFFICULTY 4%)
 IF (XX(31).NE.3) THEN
 X=UNFRN(0.,100.,1)
 C ENGINES (TOTAL 1.5%)
 C ENGINES: DELAY ONLY (1%)
 IF (X.LT.1) ATRIB(17)=TRIAC(0.,30.,60.,1)+
 ATRIB(17)
 C ENGINES: GROUNDED (.25%)
 IF (X.GT.99.75.AND.LOC.LE.3) THEN
 ATRIB(18)=1
 GO TO 900
 ENDIF
 C ENGINES: ABORT TO HOME BASE (FLYABLE) (.75%)
 IF (X.GT.99) THEN
 ATRIB(17)=TRIAC(0.,30.,60.,1)+ATRIB(17)

```

        ATRIB(18)=3
        GO TO 800
    ENDIF
    X=UNFRM(0.,100.,1)
C PROPS: SAME SEQUENCE AS ENGINES (TOTAL .75%)
    IF (X.LT.(.25)) ATRIB(17)=TRIAG(0.,15.,45.,1)+
        ATRIB(17)
    IF (X.GT.99.75.AND.LOC.LE.3) THEN
        ATRIB(18)=4
        GO TO 800
    ENDIF
    IF (X.GT.99.5) THEN
        ATRIB(17)=TRIAG(0.,30.,60.,1)+ATRIB(17)
        ATRIB(18)=4
        GO TO 800
    ENDIF
C OTHER SYSTEMS, NON-GROUNDING (TOTAL 1.75%)
    X=UNFRM(0.,100.,1)
    IF (X.LT.1) ATRIB(17)=TRIAG(0.,15.,45.,1)+
        ATRIB(17)
    IF (X.GT.99.25) THEN
        ATRIB(17)=TRIAG(0.,30.,60.,1)+ATRIB(17)
        ATRIB(18)=5
        GO TO 800
    ENDIF
C WINTER: SAME SEQUENCE AS FOR SUMMER, EXCEPT IF GNDTIM
C EXCEEDED 90 MINUTES ADD 15 MINUTES FOR EXTENDED WARMUP
C TIME. TOTAL WINTER PROB OF DIFFICULTY 5%: ENGINES 1.5%,
C PROPS 1.0%, OTHER 2.5%)
    ELSE
        IF (GNDTIM.GT.90) ATRIB(17)=25
        X=UNFRM(0.,100.,1)
        IF (X.LT.1) ATRIB(17)=TRIAG(0.,30.,60.,1)+
            ATRIB(17)
        IF (X.GT.99.75.AND.LOC.LE.3) THEN
            ATRIB(18)=3
            GO TO 800
        ENDIF
        IF (X.GT.99.5) THEN
            ATRIB(17)=TRIAG(0.,30.,60.,1)+ATRIB(17)
            ATRIB(18)=3
            GO TO 800
        ENDIF
        X=UNFRM(0.,100.,1)
        IF (X.LT.(.33)) ATRIB(17)=TRIAG(0.,15.,45.,1)+
            ATRIB(17)
        IF (X.GT.99.67.AND.LOC.LE.3) THEN
            ATRIB(18)=4
            GO TO 800
        ENDIF
        IF (X.GT.99.33) THEN
            ATRIB(17)=TRIAG(0.,30.,60.,1)+ATRIB(17)
            ATRIB(18)=4
            GO TO 800
        ENDIF
    ENDIF

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      X=UNFRM(0.,100.,1)
      IF (X.LT.1.5) ATRIB(17)=TRIAC(0.,15.,45.,1)+
        ATRIB(17)
      IF (X.GT.99) THEN
        ATRIB(17)=TRIAC(0.,30.,60.,1)+ATRIB(17)
        ATRIB(18)=5
        GO TO 800
      ENDIF
    ENDIF
  ENDIF
ENDIF
C IF AIRCRAFT ALREADY ABORTING HAS NO START PROBLEMS, CHECK
C WY BEFORE GOING HOME (THIS WILL BE AN UNSCHEDULED LEG IF
C ORIG DEST WAS NOT HOME BASE)
      IF (ATRIB(11).EQ.1.OR.ATRIB(11).EQ.2) GO TO 700
C NON-ABORTING ACFT OR ACFT ABORTING WITH LOAD FOR HOME
C BASE CONTINUE SCHEDULED MISSION
      ATRIB(16)=1
      RETURN
C AIRCRAFT ABORTING (ON UNSCHEDULED LEGS TO HOME BASE)
C CHECK WEATHER/THREAT -- IF RISK TOO HIGH, WAIT 60 MINUTES
C THEN TRY AGAIN, ELSE GO. ASSUME THAT ACFT WAITING TO
C GO HOME WILL NOT HAVE TO UNDERGO RISK OF RESTART EVERY
C 60 MINUTES (DOUBLE JEOPARDY) -- A33-99 WILL BYPASS
C START MALFUNCTION CHECKS. IF ALREADY AT HOME (LOC=1)
C ABORTS AND GROUNDINGS ARE TREATED THE SAME -- OFFLOAD
C AND RE-ENTER MISSION.
700      IF (LOC.EQ.1) THEN
          IF (XX(99).GE.1) PRINT 3000,TNOW,NINT(ATRIB(37)),
            NACFT
          ATRIB(16)=99
          RETURN
        ENDIF
        ATRIB(16)=1
        ATRIB(33)=99
        CALL DEDHED(LOC)
        RETURN
C AIRCRAFT ABORTING FROM START PROBLEMS ENTER AT 800,
C AIRCRAFT GROUNDED ENTER AT 900; SET UP MISSION
C INFO FOR OFFLOAD (AT CURRENT BASE IF GROUNDED OR
C AT HOME BASE IF ABORTING). AIRCRAFT ALREADY AT HOME
C BASE WILL BE ROUTED TO HOME BASE OFFLOAD. AIRCRAFT
C AT ANY BASE WITH A11 (ABORT FLAG) = 1 OR 2 ARE ALREADY
C SET UP TO RETURN HOME IN ABORT STATUS -- ATTRIBUTES
C WILL NOT NEED TO BE READJUSTED. (ACFT WITH A11>0 WILL
C NEVER REACH RESTART AT HOME BASE, SO THE PROBLEM OF
C ABORTING AN ABORT AT HOME BASE WILL NEVER OCCUR.)
800      IF (XX(98).GE.1) PRINT 1000,TNOW,NINT(ATRIB(37)),
        LOC,NACFT
          IF (ATRIB(11).GE.1) THEN
            CALL MTRACE(10)
            GO TO 700
          ENDIF
C CHECK FOR EMPTY ACFT OR POSITION LEG ACFT DUE TO PICK
C UP MSN AT NEXT BASE.
      IF (ATRIB(13).EQ.0.AND.ATRIB(14).EQ.0) THEN

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      IF (ATRI(23).GE.1) THEN
        CALL RESCH
        ATRI(37)=70000+LOC*1000+XX(30)*100+XX(28)
      ENDIF
      ATRI(11)=2
      ATRI(15)=1
      CALL MTRACE(10)
      GO TO 700
    ENDIF
  C IF ACFT HAS NOT PREVIOUSLY ABORTED AND IS GOING TO
  C TO HOME BASE WITH A LOAD, SET ABORT FLAG FOR END-HOME
  C OR THROUGH-HOME MISSION AND ARRANGE CARGO DATA FOR
  C RE-ENTRY OF CONTINUATION MISSION AT HOME BASE.
    IF (ATRI(20).EQ.1) THEN
      IF (ATRI(23).LE.1) THEN
        ATRI(11)=4
      ELSE
        ATRI(21)=AMAX1(ATRI(13),ATRI(21),ATRI(22))
        ATRI(14)=AMAX1(ATRI(13),ATRI(14),ATRI(22))
        ATRI(11)=3
      ENDIF
      CALL MTRACE(10)
      GO TO 700
    ENDIF
  C FOR ACFT NOT ORIGINALLY SCHEDULED TO GO TO HOME BASE ON
  C THIS LEG (NON-HOME MSN) RESTRUCTURE MISSION DATA FOR
  C OFFLOAD OF ALL CARGO AT HOME BASE AND RE-ENTRY OF
  C CONTINUATION MISSION AT HOME BASE.
    DO 851 K=32,23,-1
      ATRI(K)=ATRI(K-3)
851   CONTINUE
      ATRI(22)=ATRI(14)
      ATRI(14)=AMAX1(ATRI(13),ATRI(14),ATRI(23))
      ATRI(21)=ATRI(14)
      ATRI(15)=1
      ATRI(20)=1
      ATRI(11)=1
      CALL MTRACE(10)
      GO TO 700
  C GROUNDED AIRCRAFT MUST OFFLOAD AT CURRENT BASE; IF AT HOME
  C BASE, TREAT AS ABORT (OFFLOAD AND RE-ENTER MSN). IF ALREADY
  C ABORTING AND A11=1 OR 2, LOAD IS ALREADY SET UP FOR IMMEDIATE
  C OFFLOAD AND RE-ENTRY. ALL OTHER LOADS MUST BE RECONFIGURED
  C FOR OFFLOAD AT CURRENT BASE AND RETURN TO MISSION FILE.
  C IF SCHEDULED TO BEGIN A MISSION AT NEXT BASE, THE INTENDED
  C MISSION IS IMMEDIATELY RETURNED TO THE MISSIONS FILE.
900   IF (LOC.EQ.1) GO TO 800
      IF (XX(98).GE.1) PRINT 2000,TNOW,NINT(ATRI(37)),LOC,
        NACFT
      IF (ATRI(11).EQ.1.OR.ATRI(11).EQ.2) GO TO 800
      X=AMAX1(ATRI(13),ATRI(14))
      IF (X.EQ.0) THEN
        IF (ATRI(23).NE.0) CALL RESCH
        ATRI(11)=2
        ATRI(37)=70000+LOC*1000+XX(30)*100+XX(28)

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      GO TO 999
ENDIF
DO 901 K=32,23,-1
      ATRIB(K)=ATTRIB(K-3)
901   CONTINUE
      ATRIB(22)=ATTRIB(14)
      ATRIB(21)=AMAX1(ATTRIB(13),ATTRIB(14),ATTRIB(22))
      ATRIB(14)=ATTRIB(21)
      ATRIB(11)=1
999   ATRIB(16)=99
      ATRIB(15)=LOC
      ATRIB(20)=LOC
      CALL NTRACE(10)
      RETURN
1000  FORMAT(1X,F7.1,' MSN ',I5,' GND ABORTING (START) AT ',I1,
:         ' -- ACFT# ',I2)
C12345.7 MSN 12345 GND ABORTING (START) AT 3 -- ACFT# 23
2000  FORMAT(1X,F7.1,' MSN ',I5,' GROUNDED (START) AT ',I1,
:         ' -- ACFT# ',I2)
C12345.7 MSN 12345 GROUNDED (START) AT 3 -- ACFT# 11
3000  FORMAT(1X,F7.1,' MSN ',I5,' HOME BASE START ABORT',
:         ' -- ACFT# ',I2)
C12345.7 MSN 12345 HOME BASE START ABORT -- ACFT# 22
      END

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C SUBROUTINE ENRTE CHECKS WEATHER, THREAT, AND ABORTS, THEN
C ROUTES AIRCRAFT TO APPROACH EVENT.
C     ENROUTE AIRCRAFT ARE SUBJECT TO WEATHER AND THREAT
C CONDITIONS WHICH MAY BE DIFFERENT FROM THOSE UNDER WHICH
C THE MISSION WAS SCHEDULED. IF ENROUTE CONDITIONS EXCEED
C THE RISK LEVEL FOR THE MISSION, THE AIRCRAFT ABORTS TO
C HOME BASE (ASSUMED POINT OF ABORT IS MID-LEG). MAINTENANCE
C PROBLEMS ARE ACCOUNTED FOR BY A 5% OVERALL ABORT CHANCE ON
C EACH SORTIE, WITH ABORT OCCURRING AT A RANDOM TIME DURING
C THE LEG. (BECAUSE OF THE DIFFICULTY IN ASCERTAINING WHICH
C ZONE AN AIRCRAFT WOULD BE IN WHEN ACTUALLY ABORTING, ABORTING
C AIRCRAFT ARE ASSUMED NOT TO HAVE ENCOUNTERED ANY THREATS OR
C ADVERSE WEATHER BEFORE ABORTING.) ANY AIRCRAFT RETURNING
C TO HOME BASE IN ABORT STATUS (FOR MAINTENANCE OR OTHERWISE)
C MUST OFFLOAD ITS CARGO, WHICH WILL THEN BE ENTERED AS A
C CONTINUATION MISSION.
C     IF A MISSION ALLOWS EXPOSURE TO EITHER LOW OR HIGH
C THREAT LEVELS, THE AIRCRAFT RUNS A CHANCE OF BEING LOST
C TO ENEMY ACTION IF A THREAT EXISTS AND CERTAIN ESCORT AND
C WEATHER CONDITIONS ARE NOT MET. THREAT, WEATHER, AND ESCORT
C ARE EVALUATED ON A ZONE-BY-ZONE BASIS.
C
C VARIABLES:
C      ORIG      INT      LEG ORIGINATING BASE
C      DEST      INT      LEG DESTINATION BASE
C      NACFT      INT      ACFT ID NUMBER
C      ETELEG     INT      LEG ENROUTE TIME
C      CHKTIM     REAL     CHECK TIME FOR WCHK
C      TFAIL     REAL     MX ABORT TURNAROUND TIME
C      ALLWX      INT      DEST BASE APPRCH CAPAB
C      WXFLG      INT      ENROUTE WX/THREAT INDICATOR
C      ZPTR       INT      ZONLST POINTER
C      ZONE       INT      ZONE NUMBER
C      IWX        INT      ZONE WX CONDITION
C      THRT       INT      IF 1, THREAT IN ZONE
C      FTRFLG     INT      IF 1, ESCORT AVAIL
C      X, Y       REAL     RANDOM VARIATES
C

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SUBROUTINE ENRTE
COMMON/SCOM1/ ATRIE(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,MNRUN,NNSET,NTAPE,SS(100),
: SSL(100),TNEXT,TNOW,XX(100)
COMMON/UCOM1/ ETELST(25),ZONLST(150),BASLST(25)
INTEGER ETALST,ZONLST,ETELST,BASLST,MSMETA,
: THRT,ORIG,DEST,WXFLG,ETELEG,ALLWX,FTRFLG,ZPTR,ZONE
DATA ZONLST/1,5*0,1,2,4*0,1,9,10,3*0,1,9,10,6,2*0,1,3,4,3*0,
: 2,2,1,3*0,2,5*0,2,10,4*0,2,10,6,3*0,2,9,4,3*0,
: 10,9,1,3*0,10,2,4*0,10,5*0,10,6,4*0,10,5,4,3*0,
: 6,10,9,1,2*0,6,10,2,3*0,6,10,4*0,6,5*0,6,5,4,3*0,
: 4,3,1,3*0,4,9,2,3*0,4,5,10,3*0,4,5,9,3*0,4,5*0/
DATA ETELST/ 0, 50, 60,150, 90,
: 50, 0, 60,120,150,
: 60, 60, 0, 60,120,
: 150,120, 60, 0, 90,
: 90,150,120, 90, 0/

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DATA BASLST/1,2,3,4,5,
           2,3,4,1,5,
           3,2,4,1,5,
           4,3,2,1,5,
           5,1,2,3,4/

ATTRIB(18)=1
ORIG=ATTRIB(12)
DEST=ATTRIB(15)
NACFT=ATTRIB(9)
ETELEG=ETELST((ORIG-1)*5+DEST)
CHKTIM=TNOW+ETELEG/2
TFAIL=.5*ETELEG
ALLWI=XX(DEST+80)
IF (DEST.EQ.1) ATTRIB(40)=2
C CHECK MAINTENANCE ABORT
X=UNFRM(0.,100.,1)
Y=UNFRM(0.,1.,1)
IF (X.LE.5) THEN
  TFAIL=Y*ETELEG
  IF (X.LT.1.5) THEN
    ATTRIB(18)=3
  ELSE IF (X.GE.1.5.AND.X.LT.3) THEN
    ATTRIB(18)=4
  ELSE IF (X.GE.3) THEN
    ATTRIB(18)=5
  ENDIF
  ATTRIB(2)=3
  IF (XX(98).GE.1) PRINT 2000, TNOW, NINT(ATTRIB(37)),
    ORIG, DEST, NINT(ATTRIB(2)), NINT(ATTRIB(18)), NACFT
  GO TO 500
ENDIF
C CHECK WEATHER AND THREAT FOR ABORT CONDITIONS AND NON-
C THREAT CONDITIONS
CALL WCHK(ORIG, DEST, CHKTIM, WIFLG)
IF (WIFLG.EQ.0) GO TO 100
IF (WIFLG.GE.1.AND.ATTRIB(40).EQ.0) THEN
  IF (XX(98).GE.1) PRINT 3000, TNOW, NINT(ATTRIB(37)),
    ORIG, DEST, NINT(ATTRIB(40)), WIFLG, NACFT
  GO TO 500
ENDIF
IF (WIFLG.EQ.3) GO TO 100
IF (ATTRIB(40).EQ.1) THEN
  IF (WIFLG.EQ.2.OR.WIFLG.EQ.5) THEN
    IF (XX(98).GE.1) PRINT 3000, TNOW, NINT(ATTRIB(37)),
      ORIG, DEST, NINT(ATTRIB(40)), WIFLG, NACFT
    GO TO 500
  ENDIF
ENDIF
C THREAT EVALUATION BY ZONES
DO 50 I=1,8
  ZPTR=(ORIG-1)*30+(DEST-1)*8
  ZONE=ZONLST(ZPTR+1)
  IF (ZONE.EQ.0) GO TO 100
  IWI=XX(ZONE+40)
  THRT=XX(ZONE+50)

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      IF (THRT.EQ.1.AND.IWX.NE.2) THEN
        CALL FTRCHK(ZONE,CHKTIM,FTRFLG)
        IF (FTRFLG.EQ.1) THEN
          IF (IWX.EQ.1) GO TO 50
          GO TO 30
        ENDIF
        IF (IWX.EQ.1) GO TO 20
        GO TO 40
      C LOW-THREAT ATTRITION (LOW-LEVEL, CLEAR WX, NO ESCORT)
      20      X=UNFRM(0.,100.,1)
        IF (X.LT.XX(11)) GO TO 999
        GO TO 50
      C MEDIUM-THREAT ATTRITION (LOW CLOUDS PREVENT LOW-LEVEL,
      C ESCORT AVAILABLE)
      30      X=UNFRM(0.,100.,1)
        IF (X.LT.XX(12)) GO TO 999
        GO TO 50
      C HIGH-THREAT ATTRITION (LOW CLOUDS PREVENT LOW-LEVEL,
      C NO ESCORT)
      40      X=UNFRM(0.,100.,1)
        IF (X.LT.XX(13)) GO TO 999
        GO TO 50
      ENDIF
      50      CONTINUE
      C IF AT THIS POINT, ENROUTE PORTION IS SATISFACTORY; SET
      C ENROUTE TIME AND PROCEED TO APPROACH EVENT.
      100     ATRIB(18)=1
        ATRIB(17)=NTELEG
        CALL MTRACE(5)
        RETURN
      C ABORTS
      C ALREADY ABORTING
      500     IF (ATRI(11).GE.1) GO TO 599
      C ALREADY HEADED HOME WITH LOAD FOR HOME (OR FOR HOME AND
      C SUBSEQUENT DESTINATIONS)
        IF (ATRI(15).EQ.1) THEN
          IF (ATRI(23).EQ.0) THEN
            ATRIB(11)=4
            GO TO 599
          ELSE
            ATRIB(11)=3
            ATRIB(14)=AMAX1(ATRI(13),ATRI(14),ATRI(22))
            ATRIB(21)=ATRI(14)
            GO TO 599
          ENDIF
        ENDIF
      C ON POSITION LEG (MISSION NOT YET PICKED UP)
        IF (ATRI(13).EQ.0.AND.ATRI(14).EQ.0) THEN
          IF (ATRI(23).GE.1) THEN
            CALL RESCH
            ATRIB(17)=70000+ORIG*1000+XX(30)*100+XX(26)
          ENDIF
          ATRIB(11)=2
          GO TO 599
        ENDIF

```

```

C ABORTING WITH LOAD ON BOARD FOR OTHER THAN HOME BASE
DO 501 I=32,23,-1
    ATRIB(I)=ATRI(I-3)
501 CONTINUE
    ATRIB(11)=1
    ATRIB(22)=ATRI(14)
    ATRIB(14)=AMAX1(ATRI(13),ATRI(14))
    ATRIB(20)=1
    ATRIB(21)=ATRI(14)
599 ATRIB(16)=1
C IF ABORTING ENROUTE HOME, ETE IS NORMAL LEG TIME
    IF (DEST.EQ.1) THEN
        ATRIB(17)=ETELEG
        GO TO 600
    ENDIF
C IF ABORTING ON FIRST LEG FROM HOME, TURN AROUND AT
C TIME OF FAILURE
    IF (ORIG.EQ.1) THEN
        ATRIB(17)=2*TFAIL
        GO TO 600
    ENDIF
C IF ABORTING ENROUTE FROM 4 OR 5 TO 2 OR 3 (INBOUND FROM
C OUTLYING BASES) ETE TO HOME IS NORMAL LEG TIME TO BASE
C 2 OR 3 PLUS TIME FROM 2 OR 3 TO HOME (ASSUME OVERFLY
C DESTINATION ENROUTE HOME)
    IF (DEST.EQ.2.OR.DEST.EQ.3) THEN
        ATRIB(17)=ETELEG+ETELST((DEST-1)*5+1)
        GO TO 600
    ENDIF
C FOR ALL OTHER ENROUTE ABORTS (OUTBOUND TO OUTLYING
C BASES) TURN AROUND AT TIME OF FAILURE, ROUTE TO HOME
C VIA ORIG BASE FOR THAT LEG; ETE IS DOUBLE TIME TO TURN-
C AROUND POINT PLUS TIME FROM LEG ORIG BASE TO HOME.
    ATRIB(17)=2*TFAIL+ETELST((ORIG-1)*5+1)
C PRINT ENRTE ABORT MESSAGE AND RESET DEST AS HOME BASE
600 IF (XX(98).GE.1) PRINT 4000,TNOW,NINT(ATRI(37)),
:     ORIG,DEST,ATRI(17),NINT(ATRI(11)),NACFT
    ATRIB(13)=1
    RETURN
C LOST AIRCRAFT: IF ENROUTE TO BEGIN A MISSION, RETURN THAT
C MISSION TO THE MISSION FILE. OTHERWISE, ENTIRE MISSION LOST.
999 IF (ATRI(13).EQ.0.AND.ATRI(14).EQ.0.AND.ATRI(23).GE.1)
:     THEN
        CALL RESCH
        ATRIB(37)=99999
    ENDIF
    IF (ATRI(37).GE.1.AND.ATRI(37).LT.60000) XX(23)=XX(23)+1
    XX(1)=XX(1)-1
    XX(2)=XX(2)-1
    PRINT 1000,CHKTIM,ZONE,ORIG,DEST,NINT(ATRI(37)),NACFT
    PRINT 1001,NINT(ATRI(40)),IWZ,FTRFLC
    ATRIB(16)=0
    RETURN
1000 FORMAT(1X,F7.1,' ACFT LOST IN ZONE ',I2,' -- ORIG=',I1,
:     ' DEST=',I1,' MSN=',I5,' ACFT# ',I2)

```

```

1001  FORMAT(33X,'MRISK=',I1,' WX=',I1,' ESCORT= ',I1)
C12345.7 ACFT LOST IN ZONE 10 -- ORIG=1 DEST=2 MSN=12345 ACFT# 12
C
      MRISK=2 WX=3 ESCORT=0
2000  FORMAT(1X,F7.1,' MSN ',I5,' ABORTING ENRTE (MX) ',I1,
:      ' TO ',I1,' -- MX=',I1,' MXFAIL=',I1,' ACFT# ',I2)
C12345.7 MSN 52024 ABORTING ENRTE (MX) 1 TO 3 -- MX=3 MXFAIL=4 ACFT# 1
3000  FORMAT(1X,F7.1,' MSN ',I5,' ABORTING ENRTE (THRT) ',I1,
:      ' TO ',I1,' -- RISK=',I1,' WXFLG=',I1,' ACFT# ',I2)
C12345.7 MSN 74301 ABORTING ENRTE (THRT) 1 TO 4 -- RISK=1 WXFLG=5
4000  FORMAT(1X,F7.1,' MSN ',I5,' ABORTING ENRTE ',I1,' TO ',I1,
:      ' -- ETE=',F4.0,' ABORT=',I1,' ACFT# ',I2)
C12345.7 MSN 24005 ABORTING ENRTE 2 TO 5 -- ETE=123. ABORT=4 ACFT# 23
END

```

SUBROUTINE APPRCH

```

C AFTER COMPLETION OF ENROUTE PHASE, AIRCRAFT MUST EXECUTE
C APPROACH TO DESTINATION BASE. ALTHOUGH THE WEATHER WAS
C CHECKED WHEN THE MISSION WAS SCHEDULED, IT COULD POSSIBLY
C HAVE CHANGED; THEREFORE, THE APPRCH EVENT RECHECKS THE
C WEATHER FOR THE CONCERNED BASE. IF THE BASE HAS APPROACH
C AIDS SUITABLE FOR THE WEATHER, THE AIRCRAFT IS ALLOWED TO
C LAND; IF NOT, IT IS ALLOWED TO TRY THE APPROACH WITH A
C SMALL CHANCE OF "BREAKING OUT" IN TIME TO LAND. IF
C THE APPROACH IS NOT SUCCESSFUL, THE AIRCRAFT IS ALLOWED
C MORE TRIES DEPENDING ON ITS RISK CATEGORY -- RISK LEVEL
C 0 GETS 1 TRY, LEVEL 1 GETS 2 TRIES, AND LEVEL 2 GETS 3
C TRIES. (IT IS ASSUMED THAT RISK LEVEL WILL ROUGHLY
C CORRESPOND TO MISSION PRIORITY.) TIME BETWEEN APPROACH
C TRIES IS 15 MINUTES. IF AN AIRCRAFT CANNOT LAND WITHIN
C ITS ALLOTTED TRIES, IT ABORTS TO HOME BASE FROM
C OVERHEAD DESTINATION.
C AIRCRAFT ABORTING FROM THE APPROACH EVENT ARE AUTOMATICALLY
C ASSIGNED A RISK CATEGORY OF 2 AND MUST "TAKE THEIR CHANCES"
C TRYING TO GET BACK HOME. DIVERSIONS ARE NOT ALLOWED IN THIS
C VERSION OF THE MODEL; IN ANY CASE, DIVERSIONS FROM FORWARD
C BASES ARE USUALLY TO REAR BASES, FOLLOWING THE RULE OF THUMB
C THAT ABORTED LOADS FOR OUTLYING BASES ARE RESCHEDULED MUCH
C MORE EASILY FROM MAIN BASES THAN FROM OTHER FORWARD BASES.
C THIS IS SIMILAR TO THE "HUB-AND-SPOKE" SYSTEM USED BY MANY
C AIRLINES, IN WHICH LOADS BETWEEN POINTS ON THE "RIM" ARE
C NORMALLY ROUTED THROUGH THE "HUB".
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,NCRDR,NPRNT,NMRUN,NMSET,NTAPE,SB(100),
: SSL(100),TNEXT,TNOW,XX(100)
INTEGER ORIG,DEST,WXFLG
CALL MTRACE(8)
ATTRIB(18)=1
ORIG=ATTRIB(12)
DEST=ATTRIB(15)
IF (DEST.EQ.1.OR.ATTRIB(11).GE.1) GO TO 100
C CHECK WEATHER AT DEST BASE
CALL WCHKR(ORIG,DEST,TNOW,WXFLG)
IF (WXFLG.GE.3) THEN
X=UNFRM(0.,100.,1)
C 25% CHANCE OF SUCCESSFUL APPROACH IF BELOW MINS
IF (X.LE.25) GO TO 100
C IF NO MORE TRIES, ABORT; IF MORE TRIES, ROUTE TO 15-MIN
C REPOSITIONING LEG.
IF (ATTRIB(18).GT.(ATTRIB(40)+2)) GO TO 500
CALL MTRACE(12)
ATTRIB(18)=ATTRIB(18)+1
RETURN
ENDIF
C SUCCESSFUL APPROACH
100 ATTRIB(18)=1
RETURN
C ABORT: READJUST MISSION ATTRIBUTES FOR RETURN TO MISSION
C FILE
500 IF (ATTRIB(13).EQ.0.AND.ATTRIB(14).EQ.0) THEN

```

```

      IF (ATRI(23).GE.1) CALL RESCH
      GO TO 599
    ENDIF
    DO 501 I=32,23,-1
      ATRI(I)=ATRI(I-3)
501  CONTINUE
      ATRI(11)=1
      ATRI(14)=AMAX1(ATRI(13),ATRI(14))
      ATRI(20)=1
      ATRI(21)=ATRI(14)
599  ATRI(12)=ATRI(15)
      ATRI(15)=1
      ATRI(16)=1
      ATRI(40)=2
      CALL MTRACE(11)
      RETURN
    END

```

```

SUBROUTINE MTRACE(I)
C IF XX(98) SET, PRINTS MISSION TRACE INFO
C I=1 ARRIVAL (EVENT 17) 10 GND ABORT
C 2 CONTIN 11 ABORT FR APPRCH
C 3 SCHED 12 MISSED APPRCH
C 4 DEPART (EVENT 18) 13 ENRTE ABORT
C 5 ENROUTE 14 MISSION COMPLETE
C 6 APPROACH 50 ATRIB DUMP
C 7 MSN ENTRY
C 8 ABORT
C 9 GROUNDED
C NOTE: MANY "EMBEDDED" PRINT STATEMENTS ARE INCLUDED IN THE
C VARIOUS SUBROUTINE LISTINGS; SEVERAL OF THESE ARE CONNECTED
C WITH MISSION TRACING AND ARE ALSO CONTROLLED BY XX(98).CE.1.
C OTHER EMBEDDED PRINT STATEMENTS ARE CONTROLLED BY XX(98).
C SCHED AND SCHSET PRINT STATEMENTS ARE CONTROLLED BY XX(97).
C FOR A COMPLETE TRACE OF MISSION ACTIVITIES, SET XX(98)=1 AND
C XX(99)=1. (WARNING: THE MISSION TRACE ROUTINES IN THIS
C MODEL PRINT DIRECTLY FROM THE FORTRAN CODE AND THEREFORE USE
C THE FORTRAN PRINT LIMIT WHICH MUST BE SET WHEN THE FORTRAN
C CODE IS COMPILED. THE PROGRAM MAY "BOMB" IF THIS LIMIT IS
C NOT SET TO AT LEAST 5000 LINES PER RUN TO BE TRACED -- SAMPLE
C FOR 5 RUNS: FTNS,I=SOURCE,B=MAIN,LO=0,ANSI=0,PL=25000.
C THE SLAM TRACE AND OUTPUT ROUTINES ARE GOVERNED BY THE
C SLAM PRINT LIMIT, WHICH IS SET BY THE SLAM CONTROL CARD --
C SEE BEGINNING OF NETWORK LISTING IN APPENDIX A.)
C
COMMON/SCOM1/ ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
: MSTOP,NCLNR,MCRDR,NPRNT,MNRUN,MNSET,NTAPE,SS(100),
: SSL(100),TTEXT,TNOW,XX(100)
NACFT=ATRIB(9)
IORIG=ATRIB(12)
LON=ATRIB(13)
LOFF=ATRIB(14)
IDEST=ATRIB(15)
MX=ATRIB(2)
MFLY=ATRIB(3)
MCDAY=TNOW-ATRIB(10)
MTOT=TNOW-ATRIB(1)
MSRT=ATRIB(34)
MGND=ATRIB(34)
MARKA=ATRIB(1)
MARKC=ATRIB(10)
MX=ATRIB(2)
NXTON=ATRIB(21)
NXTOFF=ATRIB(22)
NXTDEST=ATRIB(23)
MRDY=ATRIB(35)
MSN=ATRIB(37)
MPRI=ATRIB(39)
MRISK=ATRIB(36)
NDEST3=ATRIB(28)
NDEST4=ATRIB(29)
NDEST5=ATRIB(32)
LSVC=ATRIB(17)

```

```

MMRISK=ATRIB(4)
MMPRI=ATRIB(5)
MMRDY=ATRIB(1)
MMON=ATRIB(21)
MMOFF=ATRIB(22)
MMON2=ATRIB(24)
MMOFF2=ATRIB(25)
MMSN=ATRIB(3)
MORIG=ATRIB(20)
MIFAIL=ATRIB(18)
NABORT=ATRIB(11)

C STAT COLLECTION: SOME STATISTICS ARE COLLECTED ON CALLS TO
C MTRACE
IF (I.EQ.1) CALL COLCT(ATRIB(34),9)
IF (I.EQ.4) CALL COLCT(ATRIB(34),(IORIG+3))
IF (I.EQ.3.AND.MSN.GT.0.AND.(MSN.LT.60000.OR.
      MSN.GT.90000)) THEN
      STAT12=TNOW-MRDY
      CALL COLCT(STAT12,12)
ENDIF
IF (I.EQ.14.AND.MSN.GT.0.AND.(MSN.LT.60000.OR.
      MSN.GT.90000)) THEN
      STAT11=TNOW-MRDY
      CALL COLCT(STAT11,11)
ENDIF

C MISSION TRACE
IF (IX(98).GE.1) THEN
  IF (I.EQ.1) PRINT 1000,TNOW,MSN,IDEST,IORIG,LON,LOFF,
    NITON,MSRT
1000  FORMAT (1X,F7.1,' MSN ',15,' ARR ',11,' FROM ',11,
  ' -- ON=',11,' OFF=',11,' NITON=',11,' SORTIE=',14)
C12345.7 MSN 12345 ARR 1 FROM 3 -- ON=1 OFF=1 NITON=2 SORTIE=1234
  IF (I.EQ.2) PRINT 2000,TNOW,MSN,IORIG,IDEST,LON,LOFF,
    NITON,NITDEST
2000  FORMAT (1X,F7.1,' MSN ',15,' CONTIN ',11,' TO ',11,
  ' -- ON=',11,' OFF=',11,' NITON=',11,' NITDEST=',11)
C12345.7 MSN 12345 CONTIN 1 TO 3 -- ON=1 OFF=1 NITON=1 NITDEST=1
  IF (I.EQ.3) PRINT 3000,TNOW,MSN,IDEST,NITDEST,NDEST3,
    NDEST4,NDEST5,MPRI,MRDY,LON,NACFT
  IF (I.EQ.3) PRINT 3001,MFLY,MCDAY,MTOT
3000  FORMAT (1X,F7.1,' MSN ',15,' SCHED',5(1X,11),' -- MPRI=',
  11,' MRDY=',15,' ON=',11,' ACFT# ',12)
3001  FORMAT (19X,' TFLY=',14,' TCREW=',14,' TTOT=',15)
C12345.7 MSN 12345 SCHED 1 2 3 4 5 -- MPRI=1 MRDY=12345 ON=1 ACFT#1
C      TFLY=1234 TCREW=1234 TTOT=12345
  IF (I.EQ.4) PRINT 4000,TNOW,MSN,IORIG,IDEST,LON,
    LOFF,MCND,NACFT
4000  FORMAT (1X,F7.1,' MSN ',15,' DEP ',11,' FOR ',11,
  ' -- ON=',11,' OFF=',11,' GNDTIM=',15,' ACFT# ',12)
C12345.7 MSN 12345 DEP 1 FOR 5 -- ON=1 OFF=1 GNDTIM=12345 ACFT# 12
  IF (I.EQ.5) PRINT 5000,TNOW,MSN,IORIG,IDEST,LSVC,MX
5000  FORMAT (1X,F7.1,' MSN ',15,' ENROUTE FROM ',11,' TO ',
  11,' -- ETE=',13,' MX=',11,' ON=',11)
C12345.7 MSN 12345 ENROUTE FROM 1 TO 2 -- ETE=123 MX=1 ON=1
  IF (I.EQ.6) PRINT 6000,TNOW,MSN,IDEST,MX,NABORT,NACFT

```



```

6000  FORMAT (1X,F7.1,' MSN ',15,' BEGIN APPR TO ',11,
      ' -- MX=',11,' ABORT=',11,' ACFT# ',12)
C12345.7 MSN 12345 BEGIN APPR TO 1 -- MX=1 ABORT=0 ACFT# 23
      IF (1.EQ.7) PRINT 7000,TNOW,MMSN,MORIG,MMPRI,MMRDY,MMRISK
      IF (1.EQ.7) PRINT 7001,MORIG,NITDEST,NDEST3,
      NDEST4,NDEST5,MMON,MNOFF,MMON2,MNOFF2
      IF (1.EQ.7) PRINT 7002,MRISK
7000  FORMAT (1X,F7.1,' MSN ',15,' ENTERED AT ',11,
      ' -- MPRI=',11,' MRDY=',15,' MRISK=',11)
7001  FORMAT (10X,'ITIN ',5(11,1X),' ON=',11,' OFF=',11,
      ' ON=',11,' OFF=',11)
7002  FORMAT (10X,'ETE RETURN TO 1=',14)
C12345.7 MSN 12345 ENTERED AT 1 -- MPRI=1 MRDY=12345 MRISK=1
C      ITIN 1 2 3 4 5 ON=1 OFF=2 ON=1 OFF=2
C      ETE RETURN TO 1=1000
      IF (1.EQ.8) PRINT 8000,TNOW,MSN,IORIG,LON,LOFF,MX,MXFAIL
8000  FORMAT (1X,F7.1,' MSN ',15,' ABORTING FROM ',11,' -- ON=',
      11,' OFF=',11,' MX=',11,' MXFAIL=',11)
C12345.7 MSN 12345 ABORTING FROM 3 -- ON=1 OFF=2 MX=1 MXFAIL=4
      IF (1.EQ.9) PRINT 9000,TNOW,MSN,IDEST,MXFAIL
9000  FORMAT (1X,F7.1,' MSN ',15,' GROUNDED AT ',11,
      ' -- MXFAIL=',11)
C12345.7 MSN 12345 GROUNDED AT 3 -- MXFAIL=3
      IF (1.EQ.10) PRINT 10000,TNOW,MSN,IORIG,MXFAIL,NABORT
10000 FORMAT (1X,F7.1,' MSN ',15,' GND ABORTING FROM ',11,
      ' -- MXFAIL=',11,' ABORT=',11)
C12345.7 MSN 12345 GND ABORTING FROM 3 -- MXFAIL=4 ABORT=4
      IF (1.EQ.11) PRINT 11000,TNOW,MSN,IORIG,MX,NABORT
11000 FORMAT (1X,F7.1,' MSN ',15,' ABORTING OVHD ',11,
      ' -- MX=',11,' ABORT=',11)
C12345.7 MSN 12345 ABORTING OVHD 4 -- MX=3 ABORT=1
      IF (1.EQ.12) PRINT 12000,TNOW,MSN,IDEST
12000 FORMAT (1X,F7.1,' MSN ',15,' MISSED APPR AT ',11)
C12345.7 MSN 12345 MISSED APPR AT 4
      IF (1.EQ.13) PRINT 13000,TNOW,MSN,IORIG,IDEST,MX,NABORT
13000 FORMAT (1X,F7.1,' MSN ',15,' ABORTING ENRTE FR ',11,
      ' TO ',11,' -- MX=',11,' ABORT=',11)
C12345.7 MSN 12345 ABORTING ENRTE FR 1 TO 5 -- MX=3 ABORT=2
      IF (1.EQ.14) PRINT 14000,TNOW,MSN,IDEST,MACFT
14000 FORMAT(1X,F7.1,' MSN ',15,' COMPLETE AT ',11,
      ' -- ACFT# ',12)
C12345.7 MSN 12345 COMPLETE AT 3 -- ACFT# 23
      ENDIF
C RUN TERMINATION CHECK: XX(21) = RUN TERMINATION ENABLE SWITCH
C      XX(22) = MISSION ENTRY COUNTER
C      XX(23) = MISSION COMPLETION COUNTER
C      XX(24) = TERMINATION TIME
C ALL VARIABLES ARE SET TO ZERO BY INTLC. AS MISSIONS ARE
C ENTERED (REP(K) AND STACK) XX(22) IS INCREMENTED; AS MISSIONS
C ARE COMPLETED, XX(23) IS INCREMENTED. WHEN STACK IS EXHAUSTED,
C XX(21) IS SET TO 1, STOPPING ALL FURTHER "PRIMARY" MISSION ENTRY.
C WHEN MISSIONS COMPLETE EQUALS MISSIONS ENTERED, XX(21) IS SET TO
C 2 AND THE SCHEDULER HOLD LOOP ROUTES AIRCRAFT TO THE TERMINATION
C SECTION OF THE NETWORK INSTEAD OF TO THE 60-MINUTE HOLD. AS
C AIRCRAFT LEAVE THE SYSTEM, THE NUMBER OF AIRCRAFT (XX(1)) IS

```

```

C DECREMENTED AND U.E RATE AND CREW STATS ARE COLLECTED. (FOR
C UTE RATE. CLOSURE TIME IS SET AT FINAL MISSION COMPLETION TIME.
C (AFTER CLOSURE, ALL "RESCUE" MISSIONS AND DEADHEAD MISSIONS WILL
C BE COMPLETED.) WHEN THE LAST AIRCRAFT LEAVES THE SYSTEM (XX(1)=0)
C AN ENTITY BRANCHES TO THE TERMINATOR NODE.

```

```

      IF (I.EQ.14.AND.MSM.LT.60000) THEN

```

```

        XX(23)=XX(23)+1

```

```

        IF (XX(21).EQ.1.AND.XX(22).EQ.XX(23)) THEN

```

```

            XX(21)=2

```

```

            XX(24)=TNOW+180

```

```

            CALL COLCT(TNOW,13)

```

```

        ENDIF

```

```

    ENDIF

```

```

C COMPRESSED ATRIB DUMP (ONLY IF XX(98).GE.3)

```

```

      IF (XX(98).GE.3.AND.I.EQ.50) THEN

```

```

        DO 55 J=1,40

```

```

          NN=ATRI(J)

```

```

55      CONTINUE

```

```

          PRINT 50000

```

```

          PRINT 50001,(NN(K),K=12,15),(NN(K),K=20,32)

```

```

          PRINT 50002

```

```

          PRINT 50003,(NN(K),K=33,40),NN(1)

```

```

50000 FORMAT(1X,' 12 13 14 15 20 21 22 23 24 25 26 27 28 29 30 31 32')

```

```

50001 FORMAT(1X,17I3)

```

```

50002 FORMAT(1X,' 33    34    35    36    37    38    39    40    1')

```

```

50003 FORMAT(1X,9(I5,1X))

```

```

C 12 13 14 15 20 21 22 23 24 25 26 27 28 29 30 31 32

```

```

C  1  2  2  2  2  3  2  0  0  0  0  0  0  0  0  0  0

```

```

C 33   34   35   36   37   38   39   40   1

```

```

C12345 12345 12345 12345 12345 12345 12345 12345 12345

```

```

      ENDIF

```

```

      RETURN

```

```

      END

```

Appendix C
Mission Input

MISSION INPUT DATA FILE "MSTACK"

THIS MISSION INPUT APPROXIMATELY REPRESENTS A TWO-BATTALION (PLUS) MOVE FROM THE MAIN BASES TO THE FORWARD AIRHEAD. ALTHOUGH PATTERNED AFTER THE ARCTIC CIRCLE EXERCISE, IT IS SUBSTANTIALLY MORE DEMANDING.

RELATED MISSIONS HAVE SIMILAR NUMBERS FOR EASE OF ENTRY AND CHECKING. COMMENTS IN RIGHT MARGIN ARE FOR EXPLANATION ONLY AND DID NOT APPEAR IN THE MISSION INPUT FILE ACTUALLY USED.

SEE LISTING FOR SUBROUTINE STACK IN APPENDIX B FOR DETAILS ON MSTACK MISSION ENTRY FORMAT AND BASE/LOAD CODES.

TRDY (MIN)	MSN NO	RSK PRI	ITINERARY					
			LEG 1	LEG 2	LEG 3	LEG 4		
00000	2	10001	2	1	1 3 3 2	0 0 0	0 0 0	*** FIGHTER ALERT
00000	2	10002	2	1	1 3 3 3	0 0 0	0 0 0	BASE MX LOADS
00000	2	10003	2	1	1 3 2 2	0 2 3	0 0 0	
00480	1	50001	2	1	1 6 6 4	0 0 0	0 0 0	*** ALASKA ARMY
00480	1	50002	2	1	1 6 6 4	0 0 0	0 0 0	GUARD SCOUT
00480	1	50003	2	1	1 6 6 4	0 0 0	0 0 0	SUPPLY DROPS
00480	1	50004	2	1	1 6 6 4	0 0 0	0 0 0	
00480	1	50005	2	1	1 6 6 5	0 0 0	0 0 0	
00480	1	50006	2	1	1 6 6 5	0 0 0	0 0 0	
00480	1	50007	2	1	1 6 6 5	0 0 0	0 0 0	
00480	1	50008	2	1	1 6 6 5	0 0 0	0 0 0	
00720	2	31001	2	2	1 3 3 3	0 0 0	0 0 0	*** ARMY STAGING
00720	2	31002	2	2	1 3 3 3	0 0 0	0 0 0	TO BASE 3
00720	2	31003	2	2	1 3 3 3	0 0 0	0 0 0	(GALENA)
00720	2	31004	2	2	1 3 3 3	0 0 0	0 0 0	
00720	2	31005	2	2	1 3 3 3	0 0 0	0 0 0	
00720	2	31006	2	2	1 3 3 3	0 0 0	0 0 0	
00720	2	31007	2	2	1 3 3 3	0 0 0	0 0 0	
00720	2	31008	2	2	1 3 3 3	0 0 0	0 0 0	
00720	2	32001	2	2	2 3 3 3	0 0 0	0 0 0	
00720	2	32002	2	2	2 3 3 3	0 0 0	0 0 0	
00720	2	32003	2	2	2 3 3 3	0 0 0	0 0 0	
00720	2	32004	2	2	2 3 3 3	0 0 0	0 0 0	
02160	1	40001	2	1	1 5 5 4	0 0 0	0 0 0	*** FWD AIRHEAD
02160	1	40002	2	1	1 5 5 4	0 0 0	0 0 0	ASSAULT
02160	1	40003	2	1	1 5 5 4	0 0 0	0 0 0	TEAM DROPS
02160	1	40004	2	1	1 5 5 4	0 0 0	0 0 0	
02220	1	41001	2	1	1 6 6 4	0 0 0	0 0 0	*** FWD AIRHEAD
02220	1	41002	2	1	1 6 6 4	0 0 0	0 0 0	DOZER DROPS
02220	1	41003	2	1	1 6 6 4	0 0 0	0 0 0	
02280	1	41004	2	1	1 6 6 4	0 0 0	0 0 0	*** FWD AIRHEAD
02280	1	41005	2	1	1 6 6 4	0 0 0	0 0 0	INTERIM FUEL
02280	1	41006	2	1	1 6 6 4	0 0 0	0 0 0	AND SUPPLY
02640	1	41007	2	1	1 6 6 4	0 0 0	0 0 0	DROPS
02640	1	41008	2	1	1 6 6 4	0 0 0	0 0 0	
02640	1	41009	2	1	1 6 6 4	0 0 0	0 0 0	
03000	1	41010	2	1	1 6 6 4	0 0 0	0 0 0	
03000	1	41011	2	1	1 6 6 4	0 0 0	0 0 0	
03000	1	41012	2	1	1 6 6 4	0 0 0	0 0 0	

03380	1	41013	2	1	1	8	8	4	0	0	0	0	0	0	0	0	0
03380	1	41014	2	1	1	8	8	4	0	0	0	0	0	0	0	0	0
03380	1	41015	2	1	1	8	8	4	0	0	0	0	0	0	0	0	0
03720	1	42001	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42002	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42003	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42004	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42005	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42006	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
03720	1	42007	2	2	1	2	2	4	0	0	0	0	0	0	0	0	0
03720	1	42008	2	2	1	2	2	4	0	0	0	0	0	0	0	0	0
03720	1	42009	2	2	1	1	1	4	0	0	0	0	0	0	0	0	0
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03735	1	42048	2	2	1	3	3	4	0	0	0	0	0	0	0	0	0
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03735	1	42050	2	2	1	3	3	4	0	0	0	0	0	0	0	0	0

*** FWD AIRHEAD
MAIN FLOW
FROM BASE 1

210

THE COMPANY INSERTION AIRDROPS ARE CONSIDERED TO SIGNAL THE FINAL ASSAULT ON THE ENEMY FORCE AND ARE THUS THE END OF THE DEPLOYMENT.

Appendix D

Glossary

Glossary

Airlift --- A general term for air transportation.

Airland --- A specific airlift employment mode involving delivery of cargo or personnel via landing at a destination airfield.

Airdrop --- A specific airlift employment mode involving delivery of cargo or personnel via parachute, not necessarily at an airfield.

Airmobile --- A general term describing movement of army forces by helicopter.

Alaskan Air Command --- The major air command responsible for the air defense of Alaska.

ARCTIC CIRCLE --- A joint Air Force-Army field exercise which simulated the move of an Army light infantry battalion to the western part of Alaska; conducted in April 1980.

Attu and Kiska --- Small islands at the western end of the Aleutian Chain; occupied by Japan 1942-1943.

Bare-base --- Term describing an airport with minimal or nonexistent facilities.

Cannibalisation ("canning") --- Use of parts from one aircraft to repair another.

Chalk --- An Army load.

CH-47 --- "Chinook"; Army heavy-lift helicopter.

CNAF --- Civil Reserve Air Fleet.

Closure time --- Time of completion of the last mission in a series of missions.

Cobra --- Army helicopter gunship.

Combat offload --- Procedure for offloading palletized cargo without use of MHE.

Contingency --- In the context of this paper, wartime.

CONUS --- The 48 contiguous United States.

Eleventh Air Force --- Created at the beginning of World War II to oversee air activity in Alaska; later became Alaskan Air Command.

FEBA --- Forward Edge of Battle Area; front line.

FMC --- Fully Mission Capable.

Forward airhead --- An airfield (often unimproved) near a battle area which can be used as a supply point for front-line forces.

Forward area --- In Alaska, the northern, western, and southwestern parts of the theater; those areas closest to the northern and western perimeters of the theater.

GAMA GOAT --- A six-wheeled, articulated Army all-terrain vehicle.

GCI --- Ground Controlled Intercept

HF --- High-frequency; shortwave radio.

IFR --- Instrument Flight Rules; flight in non-visual conditions.

Instrument approach --- A prescribed pattern using electronic navigation aids used to position an aircraft on the final approach to the runway; in most cases, only one aircraft at a time may execute such an approach.

JACK FROST --- A biennial (formerly annual) JCS-directed winter exercise in central Alaska, normally involving less than 20,000 personnel, including support forces, and designed to test general winter employment concepts in a controlled cold-weather situation. (Note: This exercise is now called **BRIM FROST**.)

JCS --- Joint Chiefs of Staff

K-loader --- Special highly maneuverable flatbed vehicle used to offload/unload several pallets at once; a 25K-loader can handle up to 25000 pounds, etc.

Light infantry --- Army infantry units with minimum motorized support; roughly analogous to mountain troops and intended to be mobile in extremely adverse terrain with as little logistics support as possible.

Low-level --- Generally, visual flight below about 1000 feet above the ground; can include either terrain-following or terrain-avoidance flight; primary concealment technique for airlift aircraft.

M-14 --- A large simulation model used by MAC to study the worldwide strategic airlift system; formerly known as "Colossus".

MAC --- Military Airlift Command

Maximum-effort landing --- A landing which requires heavy use of brakes and reverse thrust; sometimes called a shortfield landing.

MHE --- Materials Handling Equipment; forklifts, K-loaders, etc.

Muskeg --- A type of terrain common in more moist northern regions; typically swampy and nearly impassable, and with little or no weight-bearing capability.

NMC --- Not Mission Capable.

NORS --- Non-Operationally Ready due to Supply; no longer used -- replaced by NMCS (Not Mission Capable due to Supply).

Northern latitude --- For the purposes of this paper, those areas of North America (including all of Alaska), Asia, and Europe north of approximately 55 degrees north latitude and characterized by sparse population, widely separated population centers, and limited transportation networks.

"Outside" --- Term used in Alaska to refer to CONUS.

PMC --- Partially mission capable.

Railbelt --- Term denoting the relatively developed area of Alaska centered along the Alaska Railroad.

RDF --- Rapid Deployment Force.

SAC --- Strategic Air Command.

SKE --- Stationkeeping Equipment; intra-formation positioning equipment which allows formation flight in non-visual conditions.

SLAM --- Simulation Language for Alternative Modeling.

Special operations --- When referring to airlift, operations of a semi-clandestine nature usually requiring operations within enemy territory, often employing special airdrop and airland techniques.

TACET --- Tactical Airlift in the Central European Theater; a simulation model resulting from an Air War College Tactical Air Warfare Study.

Tactical airlift --- Also called intratheater airlift; airlift used within a theater, as differentiated from strategic, or intertheater airlift; the primary tactical airlift aircraft is the C-130 Hercules.

TAM --- Theater Airlift Model; the MAC version of the TACET model.

Terrain-avoidance --- Term describing low-level flight (usually by larger, less maneuverable aircraft) which emphasizes avoidance of high terrain rather than contour-following.

Terrain-following --- Term describing flight which follows ground contours as closely as possible.

Tundra --- A type of terrain common in treeless northern regions; in summer, very soft and spongy; normally underlain by permafrost at depths of a few inches to several feet.

UH-1 --- Light general-purpose army helicopter, also known as a "Huey".

UHF --- Ultra High Frequency; aircraft line-of-sight radio.

US Army, Alaska --- Army counterpart to Alaskan Air Command.

Visual approach --- A situation in which the pilot positions the aircraft on final landing approach primarily without reference to electronic aids; generally quicker and more flexible than an instrument approach when weather conditions permit.

VFR --- Visual Flight Rules; flight in visual conditions.

VHF --- Very High Frequency; aircraft line-of-sight radio.

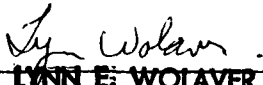
Vita of the Author

Donald S. Bowers, Jr., was born on April 1, 1948, in Fort Smith, Arkansas, where he graduated from Southside High School in 1966. In 1970 he graduated from the United States Air Force Academy with a Bachelor of Science degree in International Affairs and was commissioned into the United States Air Force. He completed pilot training at Vance AFB, Oklahoma, in July 1971. He then served as a WC-130B pilot in the 53rd Weather Reconnaissance Squadron at Ramey AFB, Puerto Rico, until October 1973, when he was assigned as an AC-130H "Spectre" gunship aircraft commander and instructor pilot at Ubon and Korat RTAFBs, Thailand. From February 1975 until May 1978 he was an instructor pilot in the 17th Tactical Airlift Squadron at Elmendorf AFB, Alaska, and flew the C-130A, C-130D-6, and C-130E. In May 1978 he moved to the 616th Military Airlift Group Staff at Elmendorf as Assistant Chief of Combat Operations and Plans, in which capacity he assisted in the planning and execution of numerous exercises (including ARCTIC CIRCLE) and helped to revise the primary Alaskan theater airlift contingency plans. He entered the Strategic and Tactical Sciences program at the Air Force Institute of Technology in August 1980. Captain Bowers is not married.

Permanent Address: 6918 Free Ferry Road
Fort Smith, Arkansas 72801

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study develops a computer simulation model of the Alaskan theater airlift system. The model makes a number of assumptions concerning system composition and operation, but is largely based on conditions and operational concepts prevailing in the theater since 1978. In general, the model centralizes the system around a home base and circulates C-130 aircraft through a network of five bases representing the major types of bases expected to be of concern in the theater. The model is written in SLAM, using extensive FORTRAN		

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Inserts, and is designed to allow considerable user flexibility and control. In particular, the user can precisely define the missions to be input and can pre-set almost all system parameters, thus permitting examination of many different scenarios and conditions.

The model was used to make an illustrative analysis of a 197-mission Army move to the western perimeter of Alaska. Using a 32-run fractional factorial design, 15 factors were screened for significant effects on the final completion time of the mission stream. With the aid of a normal probability plot and an analysis of variance, five factors (numbers of aircraft and aircrews, length of crew day, season, and weather) were found to be significant. Aircraft and aircrew effects were then explored using a triply replicated 60-cell factorial design with graphical analysis of the results. The results indicated that aircraft and aircrews have a complex but easily defined effect on closure time, and that optimum manning ratios can be readily identified. Overall, the model is believed to be a viable tool for analysis of the Alaskan airlift system, and perhaps can also be used to draw inferences concerning other theaters with similar characteristics.

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